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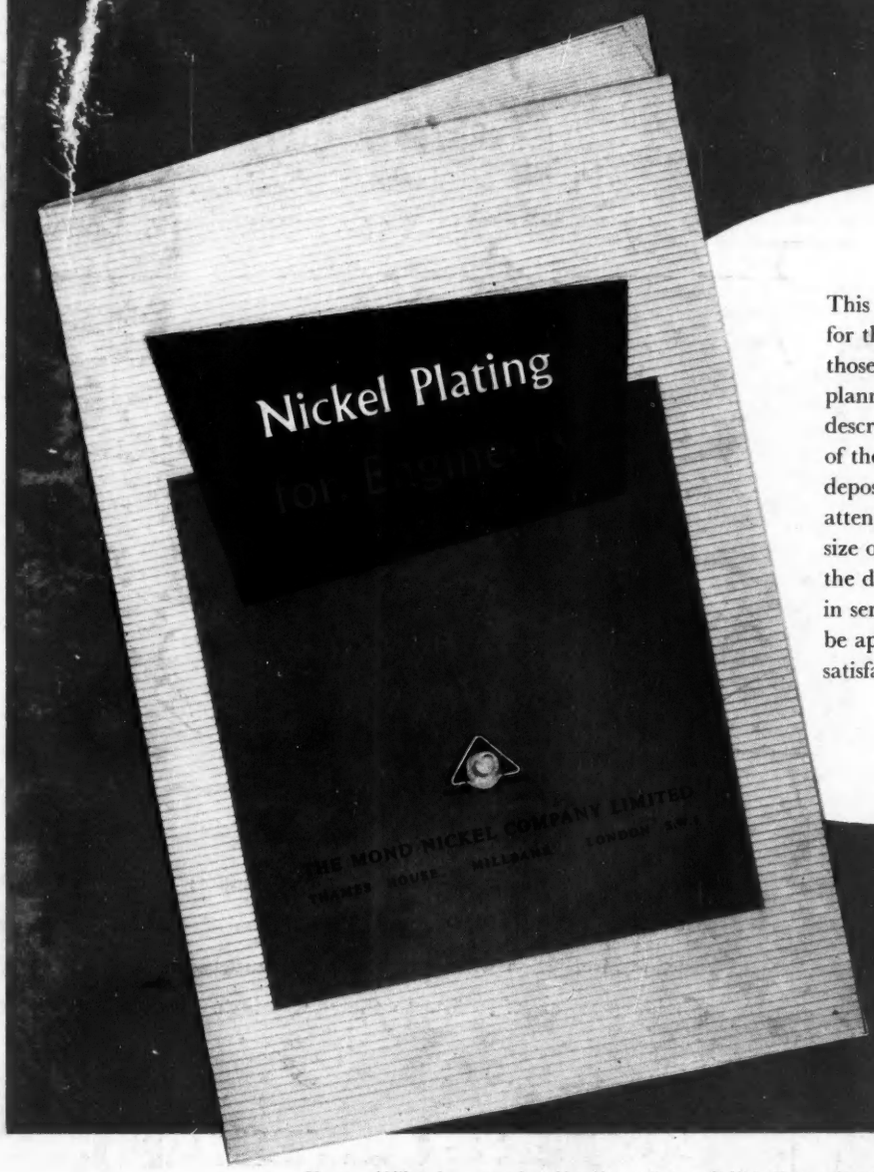


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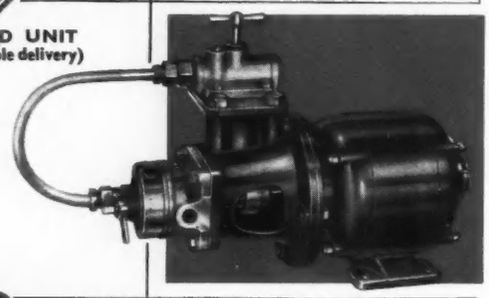

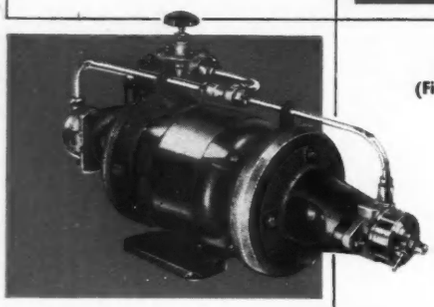

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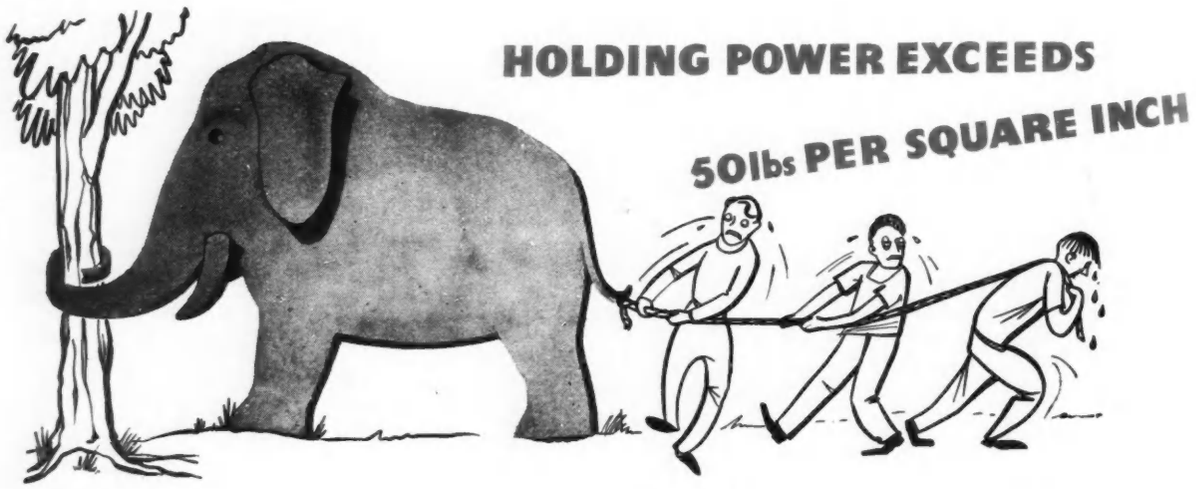


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## WORKING TO A PROGRAMME

The announcement made by Lord Mills, the Minister of Power, on March 5, of the Government's new programme for the development of nuclear power should now enable industry to plan realistically for the next few years. For many months it had been recognised that the original White Paper plan was far less than could be achieved, and on several occasions the Government appeared to be on the verge of announcing a speeding up of this programme. Now we learn that the objective is a total nuclear generating capacity of between 5000MW and 6000MW to be installed by the end of 1965. The proposals contained in the original programme have thus been trebled. That it has been possible to make such a drastic revision to a programme which itself seemed bold when first put forward two years ago is due to a number of factors. There is, for example, little doubt that the Calder Hall type of reactor, even though designed on extremely conservative lines, has proved more successful than anyone would have been willing to forecast a few years ago. Closer examination and study of some of the more advanced systems has also shown that despite the optimism of many speakers at the Geneva Conference eighteen months ago, these alternative designs, which might be cheaper to build, are not just round the corner waiting to be exploited. On some of them, experimental work of several years' duration needs to be carried out before it can be shown that the potential gains are not to be achieved at the expense of safety and reliability. As we have remarked before, the rate of advance in the nuclear power field depends to a large degree on metallurgical research, and it has to be recognised that the accumulation of data sufficient to predict accurately the behaviour of materials under the arduous conditions required in nuclear reactors can only be a slow and laborious process. Thus, although the gas-cooled graphite-moderated reactor requires very heavy capital investment, the scale of this investment now seems to be justified. This particular reactor system can no longer be regarded as a temporary stop gap prior to the building of different and very much more advanced systems.

The new programme and the possible export market for reactors offer a real challenge to British industry. Lord Mills has said that the Government is taking steps to ensure that the steel needed will be available, and presumably the remark can be taken to apply to special nuclear materials such as uranium and graphite. The initiative will now rest with the designers and builders of the new stations, and for the time being the reputation of this country in the field of heavy engineering will depend on whether the target set can be met. Because of the difficulty of finding suitable sites, and the lower capital costs to be obtained by building bigger units, there will be every incentive to obtain higher outputs by increasing the capacity of each reactor. This objective requires either a larger pressure vessel or a higher gas pressure than that used at Calder, or both. This trend has already been revealed in the designs for the stations now being built for the Central Electricity Authority. In fact, the design of very large pressure vessels has become one of the more important developments associated with the nuclear power programme. Yet, though there is so much to be gained by advances along this line, it is a path that must be pursued with reasonable caution. On no account must new advances get so far away from current experience as to risk the safety of the presssure vessel during operation.

What is ultimately feasible, however, will not be solely due to advances in methods of design or stress calculation, but much will depend on the development of the methods of fabrication adopted on the construction sites. It is here that really imaginative thinking, not only on technical matters but also on the subject of organisation of both job and labour is required. It may well be that a completely new approach to the organisation of some aspects of the site work needs to be developed. For example, with a number of sites under construction simultaneously, there will be a considerable demand for welders capable of doing Class A work in the field. Are such men available ? On this work the best results are obviously obtained by well-trained teams which do not have a rapid turnover of personnel. Unless this sort of problem is thought about now and proper plans laid accordingly then the target completion dates for the whole nuclear power programme could well begin to slip. Though with atomic energy the main interest tends to be centred on the revolutionary scientific developments and design problems, the completion to time of the new programme will, to a very large extent, ultimately depend on the skill with which the various aspects of each job are organised. The problems, for example, that have to be faced on site are not ones that will solve themselves.

The close interlinking of civil, mechanical and electrical work, the planning of heavy lifts, the high quality of welding required, the standards of cleanliness during the later stages of construction, and many other aspects of the work demand the most careful planning and execution. Engineers responsible for this work cannot rely solely on a wide background experience gained on other constructional jobs and therefore considerable foresight and initiative will be demanded of them. In fact, it is just as important that engineers should be trained to do this work well as it is to teach them how to design nuclear reactors. Reactor designs will undoubtedly have a profound effect on the way in which work can be organised on site. It therefore becomes imperative that the problems of site work shall be intelligently appreciated and brought forward at the design stage, so that the best all round results, with the greatest economy of skilled labour, may eventually be obtained.

### SHIPBUILDING CHALLENGE

The Annual Summary published by Lloyd's Register of Shipping, giving the totals of merchant ships launched in 1956, is a document well worth studying at this time when a strike threatens in the shipbuilding industry. It suggests that the prosperity of the industry is brittle. The Summary confirms the totals given in the Society's returns issued for the last quarter of 1956. Japan's total of 1,746,000 tons gross launched in 1956 is more than double the 1955 total of 829,000 tons, while the output from the yards of Great Britain and Northern Ireland of 1,383,000 tons gross represents a recession from the 1955 total, which reached 1,474,000 tons. This rapid advance in Japan of shipbuilding output is also clearly seen in the shipbuilding returns, published by the Society in January last, which reveal increases in the categories of tonnage commenced and completed. Tonnage commenced by Japan was 1,035,000 tons in 1955 and 2,038,000 tons in 1956, while the tonnage completed for the two years was 561,000 and 1,538,000 tons, respectively. Against these totals the comparative figures for Great Britain and Northern Ireland were 1,378,000 and 1,343,000 tons commenced and 1,322,000 and 1,457,000 tons completed. The tonnage of ships launched expressed as a percentage of world output shows that Japan's shares for 1955 and 1956 were 15·6 and 26·2 per cent, respectively, while the corresponding figures for this country were 27·7 and 20·7 per cent. Other information published by Lloyd's, giving totals of merchant ships under construction, showed that Japan's total, at the end of 1955, of 832,000 tons gross, or 12·6 per cent of the world total, increased to 1,364,000 tons, or 16·9 per cent in 1956, the comparative totals for this country being 2,226,000 tons, or 33·7 per cent, and 2,135,000 tons, or 26·5 per cent.

These figures leave no doubt that Japan has taken over the leadership in the launching of ships for the year 1956, the margin being 383,000 tons gross. The challenge to the supremacy held by the United Kingdom for so many years is made evident by the tonnage commenced by that country in 1955 and duly reflected in the launch total for the following year. Based broadly on this general trend it is probable that Japan will launch an even larger total in 1957, since the tonnage commenced in 1956 was practically double that of the previous year. A glance at the British returns shows that the tonnage launched in 1956 is in step with the tonnage commenced in the previous year. First place also goes to Japan in the matter of completions during 1956, although only by the small margin of 81,000 tons. But that figure represents a big advance on the position a year ago when Japan's total was 761,000 tons less than that of this country. Here again, by arbitrarily linking the tonnage launched in one year with that completed in the following, the indication is that Japan's 1957 total may record a further advance. It is true that this country has more tonnage under construction than Japan, but the figures suggest, rather ominously, that it may take only about half as long to build a ship in Japan as in this country! Why?

This overall position cannot be but disappointing to the home shipbuilding industry and no doubt there are some special factors which explain in part the year's returns. The relative proportions of oil tanker tonnage launched in the two countries were 44·2 per cent and 37·5 per cent, respectively, and since this class of tonnage is quicker to construct the position was in favour of Japan. The table giving the ships launched in the various tonnage groups shows that Japan launched a larger percentage of ships of 10,000 tons and above than did Great Britain, a situation having similar results and influenced in part by the tanker programmes. Capital investment must have played its part, but its influence is largely determined by the degree of employment of the new equipment; and the launch total compared with the total under construction rather indicates that the equipment was in fact well employed. Furthermore, constructional methods adopted and trade union influence in the matter of demarcation of work may also have contributed to the present situation. Another factor is the hours worked and perhaps conversely the hours lost, for this country was plagued by strikes in 1956. Is 1957 to prove still worse? Possibly the principal reason for Japan's expansion is that sufficient steel is available in that country, whereas it is claimed in this country that lack of steel prevents the industry from attaining its full potential of 1,750,000 tons gross per annum. Since steel in the form of a ship is a valuable export and is of even greater value as an earner of foreign currency, then the latest returns are a strong argument for the allocation of increased supplies of steel to the shipyards. But are those returns not also a cogent argument for a critical and constructive review by builders and unions in this country of shipbuilding methods? If the unions would become constructive about their restrictive practices and about demarcation troubles, builders might prove less intransigent about the present wage claim.

### PRAISE AND DISPRAISE OF THE "MECHANICALS"

Elsewhere in this issue we take note of certain announcements made in the latest issue of *The Chartered Mechanical Engineer* about past and future activities of the Institution of Mechanical Engineers. Two of these announcements deserve particular notice. The more important concerns the practical training of engineers. Just over a month ago, in

## The Engineer
### 100 Years Ago
(MARCH 13, 1857)

"ASSOCIATION OF FOREMEN ENGINEERS"

"The fifth anniversary of the Association of Foremen of the Engineering Trade was celebrated on Saturday night se'night, at River's Hotel, Salisbury-square, Fleet-street. About thirty-three members and friends sat down, and, after doing justice to an elegant and ample repast provided by Mr. Edwards, the business of the evening commenced. Mr. Sheaves, the chairman, observed, in the course of an eloquent and manly speech, that the Association was in a flourishing condition, and that it was meeting all the objects which its founders had anticipated. Previously to the formation of the society over which it was at once his pride and his privilege to preside, Mr. Sheaves stated, the foremen of the engineering firms of London were an isolated class of men, having no bond of union but that of the fellow feeling which always existed among mechanical men engaged in kindred pursuits. They had no rallying point, no organisation—no centre of action which might expedite their mutual interchanges of benefit, without which success and advancement in life were but the results of fortuitous circumstances—uncertain and doubtful. The Association of Engineering Foremen had, however, effected a consolidation of interests, which tended to the general and individual good of its members. It was not, said Mr. Sheaves, a secret society, but an open and beneficent one. It aided the diffusion of knowledge, and profiting thus employers and employed. At its monthly meetings practical and theoretical questions of importance to the mechanical community were discussed, and the varied information of the associates was brought to bear upon the inventions and discoveries of the day . . .

"Messrs. Newton, Ross, and Jones spoke as to the efficiency of the officers of the society, and then commenced the sway of harmony. At the midnight hour, or just previously to it, the National Anthem was given with an earnestness which proved the loyalty of the Associated Engineers, and delightfully closed the proceedings of the night."

discussing a publication then just issued by the Institution of Electrical Engineers entitled *The Training of Graduates*, we remarked that we did not doubt that other Institutions were studying the same problem. It now appears that the "Mechanicals" council, thinking along the same lines, has set up a committee to review the practical training of mechanical engineers. This desire of the Institutions to study the practical side of the training of professional engineers unquestionably stems from the difficulty nowadays of packing into a restricted number of years all the training, academic and practical, that a student is deemed to need. In particular, as the years have passed, there has been a growing demand for engineers possessing a more extensive and a deeper knowledge of underlying scientific principles. More and more industry is appreciating the value of such men. But it is becoming increasingly difficult to produce them within the normal three-year university course or its equivalent in a sandwich arrangement. Furthermore, it is beginning to be asked whether men whose intention it is to take up, for example, research, really need as much practical works experience as, for instance, a man interested in the production side. Something, of course, can be and is being done to pack more practical training into a smaller time by conscious efforts to plan practical training courses. Can this action be pressed far enough ? Or should the length of practical training be adapted to suit the particular field of activity which the young man chooses ? It will be interesting to learn the conclusions of the committee which, by the way, would welcome the submission of views by any Institution member caring to send them along in writing.

Less satisfaction can be expressed about the other announcement. It is that this year the Institution is to hold its Summer Meeting at Cambridge. Lest any reader should feel called at once to expostulate we hasten to add that we hold no animosity against that city. It is a very charming one and eminently suitable upon several grounds for an Institution summer meeting. What we regret is not that Cambridge should have been chosen for a summer meeting, but that it should have been chosen for this year's meeting. For a fine opportunity has been lost. Throughout this year negotiations will be going on towards the setting up of a European Free Trade Area. How appropriate it would have been therefore if the Institution had taken its members on to the Continent to see for themselves some of the works there with whose products they will have to compete should the Free Trade Area come into being, to see what are the conditions there and to discuss with opposite numbers there what the effect of setting up the Area is likely to be. What a pity the opportunity has been lost !

# A Seven Day Journal

### Practical Training of Mechanical Engineers

THE council of the Institution of Mechanical Engineers decided recently to set up a committee to review the subject of the practical training of mechanical engineers, and to tender advice as to whether any changes are desirable in the manner in which the relevant by-laws of the Institution are interpreted. Under the Institution's by-laws, a candidate eligible for corporate membership must produce satisfactory evidence that he has been "regularly trained as a mechanical engineer," regular training being interpreted as "a period of not less than eighteen months in mechanical engineering workshops in industry." The importance of practical training is fully acknowledged, though it is realised that there are no absolute standards by which it can be assessed. The Institution has lately remarked on the individual expressions of opinion which have been forthcoming, that not all present practical training schemes for university graduates in mechanical engineering are suited to contemporary needs, particularly in so far as the methods used and the content of courses are concerned. The committee which has been set up wishes to make it known that it is undertaking a review of practical training, in order to give as much opportunity as possible to any member of the Institution who so desires to submit his views, in writing, for consideration. The Institution says that this rather unusual step is being taken because practical training standards affect not only the progress of all those who are preparing to follow a career in mechanical engineering, but also the quality of the practice of mechanical engineering itself.

### Institute of Marine Engineers' Annual Dinner

SIR DONALD F. ANDERSON, the president, was in the chair at the fifty-fourth annual dinner of the Institute of Marine Engineers, which was attended by about 1200 members and their guests and which was held on Friday, March 8, at Grosvenor House, Park Lane, London. Mr. J. R. Rylands, the president of the Institute of Fuel, proposed the toast of "The Royal and Merchant Navies of the British Commonwealth"; broadly, he spoke of the development of diesel engines and the rise in the pressure and temperature of steam. He was emphatic that the era of cheap power would not be ushered in in the near future and went on to remark upon the development of ships and recruitment of the men to man them. In his reply, the Earl of Selkirk, First Lord of the Admiralty, commented upon the value of retaining the link between the Royal and Merchant navies in peacetime and expressed a wish that, in this era of rapid change, developments were less costly. The First Lord drew attention to the strong external challenge to Britain, but was certain that it would be met. The toast, "The Institute of Marine Engineers" was proposed by Mr. Harold Watkinson, Minister of Transport and Civil Aviation, who exhorted those present to improve the country's competitive position. He acknowledged the co-operation of the Merchant Navy with the Ministry and also referred to the need to use more machine tools, and for greater efficiency in the building and operation of ships. Sir Donald Anderson replied. He reflected that the strength of the shipping industry appeared to be in inverse proportion to the amount of Government affection. He instanced the backwardness of a state created industry, the inefficiency of the subsidised merchant fleet, and "blackmailing" effect of state aided ships, and the vigour of those fleets which receive no help but were, on the contrary, heavily taxed. The time was opportune, he considered, for an account to be rendered of the amount spent by the country on the development of engineering for air and for sea, so that a true appreciation of the relationship between them might be established.

### Birmingham Inner Ring Road

MR. HAROLD WATKINSON, Minister of Transport and Civil Aviation, formally inaugurated work on the first part of the scheme for the construction of the Birmingham inner ring road on March 8. Under this scheme it is planned eventually to build nearly 4 miles of twin carriageway road around an area that includes Snow Hill Station, New Street Station, the Town Hall and the main business centre. The estimated cost of the whole scheme is about £15,000,000. The first part, on which work was inaugurated, runs for about a quarter of a mile from Suffolk Street to Queen's Drive. It will cost £1,164,000. The new road will have twin carriageways, each 38ft wide, and two 15ft footpaths, on an overall width of 110ft. The carriageways will each provide for three 10ft lanes of moving traffic and a continuous, distinctively-coloured waiting lane, 8ft wide, for buses when stopping and for other vehicles while waiting for short periods. A viaduct will carry the new road over the existing junction of Smallbrook Street and Worcester Street with Dudley Street and Pershore Street and the Corporation intends to utilise space under the viaduct on both sides of Dudley Street for a car park. Smallbrook Street and part of Worcester Street will be replaced by the new road. The complete scheme has been designed by Sir Herbert J. Manzoni, C.B.E., M.I.C.E., the city engineer and surveyor. The main central street layout of Birmingham has altered little in the last hundred years, during which time the population has increased from about 85,000 to well over 1,000,000. The traffic problem began to be serious in the early part of this century, and the provision of an inner ring road was first envisaged in 1918 ; by 1933 the congestion in the city centre was so acute that a system of one-way streets was instituted, and was revised in 1936. Just before the last war further serious consideration was given to the ring road scheme, and in 1944 a scheme was approved by the City Council and the necessary powers obtained in the Birmingham Corporation Act, 1946.

### Britain's Road Programme

AT a luncheon following the inauguration of work on the Birmingham ring road, described in the previous note, Mr. Watkinson made a speech in which he gave his opinions on the country's road programme. He said that he did not think it was generally realised how substantial the present roads programme was, nor how far it had already been pressed on. Since April, 1955, work had started on some 2000 road schemes in England and Wales which would cost together well over £30,000,000. Even the smaller ones, he affirmed, would bring good dividends in improved traffic flow and greater

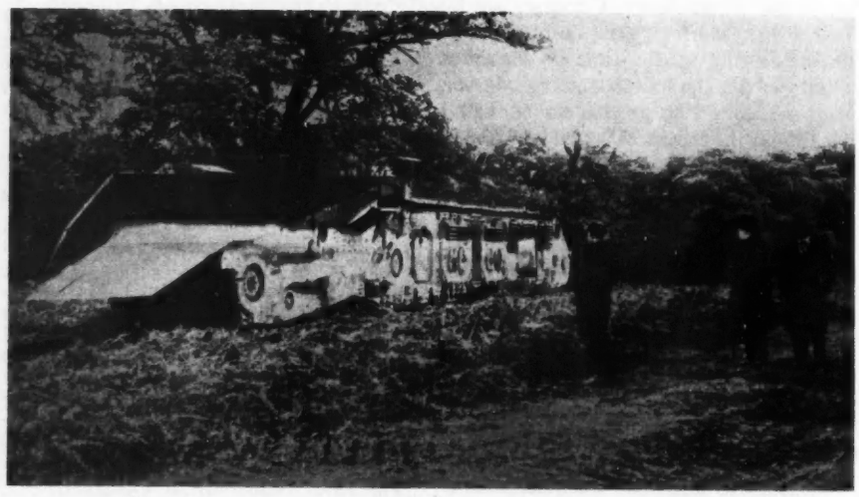
road safety. A few large schemes had already been finished ; some of them were : Neath By-pass, first section ; Llangyfelach By-pass ; Tunnel bridge at Hook near Basingstoke (A.30) ; Langstone bridge, Hayling Island; " dualling " of A.34 in Staffordshire and the " dualling " of A.40 from Oxford City to the Islip Turn. These alone had cost well over £3,000,000. Construction work was well advanced on thirty-one other large road schemes including the Cromwell Road extension (the new western exit from London), Western Avenue, London, the Preston By-pass, which was the first section of the Birmingham-Preston motorway, and seven major schemes on the Great North Road. There were several times more schemes to come, Mr. Watkinson said, than the 2000 which were already under way. It was understandable why it took time for a major roads programme to build up, he went on, but we were steadily approaching the time when we should be seeing for ourselves the results of all the painstaking preparatory work that had gone on. What he had primarily in mind in developing the road programme was a concentration of effort on a basic framework of those routes of greatest importance to the life and industry of the country, together with by-passes and urban improvements such as the Birmingham inner ring road to relieve congestion in important cities and towns. It was necessary, he considered, to strike a delicate balance here between the needs of great urban areas and the communications between them. He made no apology for saying again that new motor roads needed a commercial justification for their heavy cost. Based on these principles the basic shape of the Ministry's roads programme was as follows : (1) the Great North Road A.1, would be improved all along its length and brought up to a high standard of general purpose road. There were to be improvement schemes carried out along the whole length of that road during the present roads programme and he had already announced twenty-three of these ; (2) the London-Yorkshire motorway and, in particular, the first section from London via the Dunchurch spur to Birmingham. All being well constructional work would start on this before the end of the year ; (3) the Birmingham-Preston motor road would follow which would link up with the Preston By-pass ; (4) the road from London to South Wales, including the Severn Bridge. This would also improve communications between London and London airport ; (5) the two trunk roads from London to the Kent coast including by-passes of the Medway towns, and of Maidstone and Ashford ; (6) then there was the Ross Spur, another motor road which he hoped to start this year, to improve communications between the Midlands and South Wales. To relieve congestion in large cities and towns, works were already in progress in Swansea, Plymouth, Southampton, Portsmouth and Leeds and, of course, London, where the new Cromwell Road extension was already partly open to traffic, and other works were going ahead on Western Avenue, Watford By-pass, the Great Cambridge Road and Newbury Park Bridge on Eastern Avenue. Soon they would be starting the actual construction of the Dartford-Purfleet tunnel which would cost £12,000,000. Then there were a lot of by-passes, including the Oxford Eastern and Western By-passes, and the second part of the Neath By-pass, by-passes at Catterick and Wetherby on the Great North Road, and at Potter Street between London and Harlow and the Harlow By-pass, all of which were planned to start this year.

# Wartime Excavating Machine

*A wartime engineering achievement which did not find actual use in the field of battle, and consequently has not, to our knowledge, been described before, forms the subject of this article. It was developed at the beginning of the war, on Sir Winston Churchill's initiative, to aid offensive action against a line of fortified defences : but the character of the war developed in a different way, and the special need for the machine passed.*

MUCH has been written about the host of engineering devices of all conceivable kinds which were designed and made under the spur of the 1939-45 war, each to perform some specialised warlike task. The most successful are well known—the landing craft and " Mulberry " harbours, the special-purpose armoured vehicles, such as flail tanks, and so forth. But at least one of these devices has never been given more than passing mention, although in engineering circles it is of special interest. The device to which we refer was an excavating machine, intended to dig a trench fast enough for infantry (or tanks), to advance behind it in the shelter of the trench. The reasons why it is not well known are obvious—the war passed it by, and there was never need to use it. A description of it may, nevertheless, be found instructive.

Before the war started, and in the early days of the " twilight " war, before the offensive power of the " Panzer " divisions had been demonstrated, military thought was conditioned to accepting the dominant position of the defence. The trench warfare of the 1914-18 war, and the subsequent construction of the Maginot and Siegfried lines, invited the belief that relatively static warfare would again emerge, with all advantage to those in the defensive role. At that time Sir Winston Churchill initiated the development of the machine described here. The best idea of its purpose and function can be given by quoting his own words, in an appendix to Volume I of his war memoirs* which is given below in full.



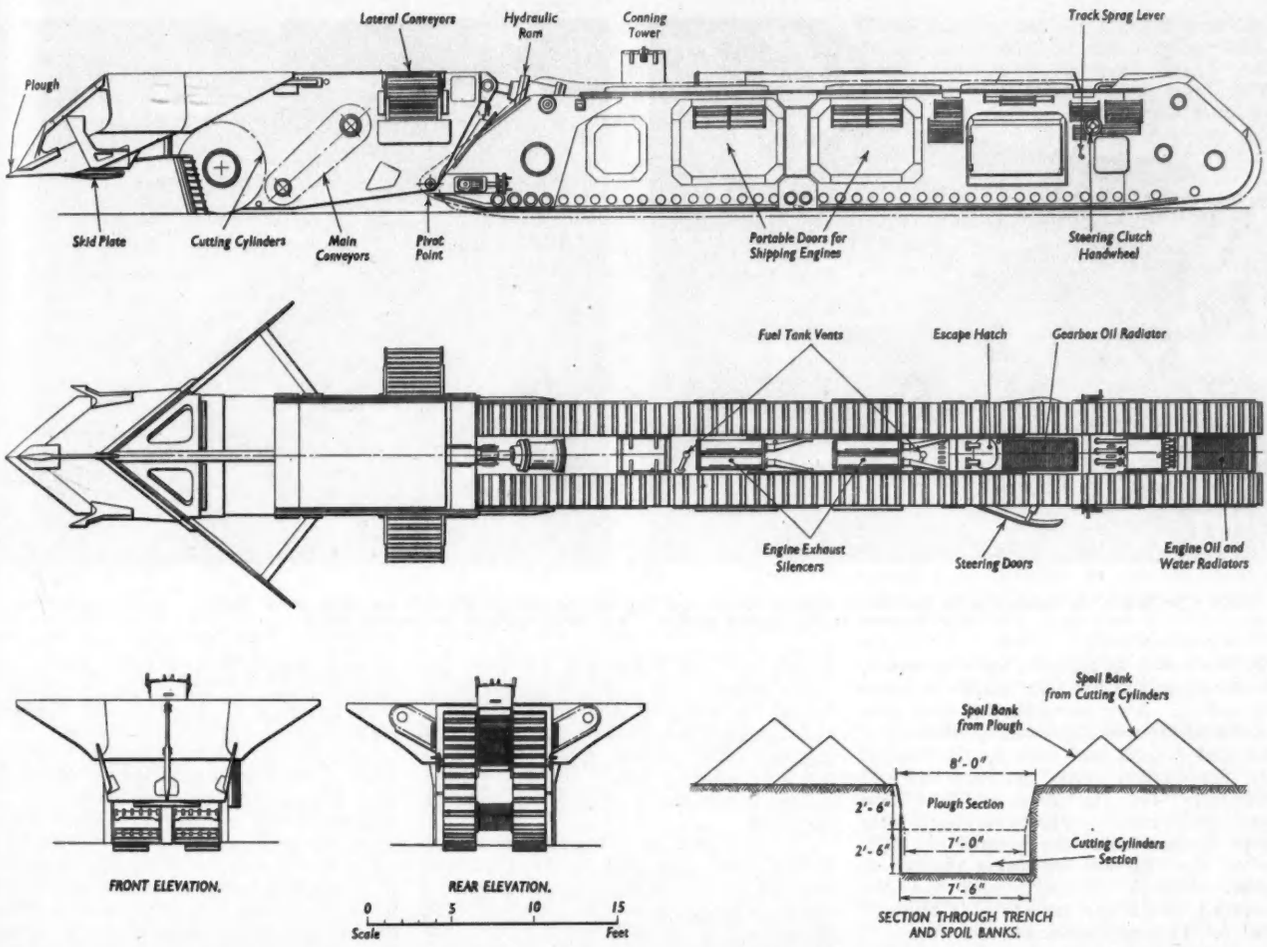
**The machine is shown here at the start of its trials. The hinged front section with plough and cutters may be noted**

### " Cultivator No. 6 "

" During these months (of late 1939)," he wrote, " I gave much thought and compelled much effort to the development of an idea which I thought might be helpful to the great battle when it began. For secrecy's sake this was called ' White Rabbit No. 6,' later changed to ' Cultivator No. 6.' It was a method of imparting to our armies a means of advance up to and through the hostile lines without undue or prohibitive casualties. I believed that a machine could be made which would cut a groove in the earth sufficiently deep and broad through which assaulting infantry and presently assaulting tanks could advance in comparative safety across no-man's-land and wire entanglements, and come to grips with the enemy in his defences on equal terms and in superior strength. It was necessary that the machine cutting this trench should advance at sufficient speed to cross the distance between the two front lines during the hours of darkness. I hoped for a speed of three or four m.p.h.; but even half-a-mile would be enough. If this method could be applied upon a front of perhaps 20 or 25 miles, for which two or three hundred trench-cutters might suffice, dawn would find an overwhelming force of determined infantry established on and in the German defences, with hundreds of lines-of-communication trenches stretching back behind them, along which reinforcements and supplies could flow. Thus we should establish ourselves in the enemy's front line by surprise and with little loss. This process could be repeated indefinitely.

" When I had the first tank made twenty-five years before, I turned to Tennyson d'Eyncourt, Director of Naval Construction, to solve the problem. Accordingly I broached the subject in November to Sir Stanley Goodall, who now held this most important office, and one of his ablest assistants, Mr. Hopkins, was put in charge with a grant of £100,000 for experiments. The design and manufacture of a working model was completed in six weeks by Messrs. Ruston-Bucyrus of Lincoln. This suggestive little machine, about three feet long, performed excellently in the Admiralty basement on a floor

* " The Second World War," Vol. I, published by Cassell and Co., Ltd.

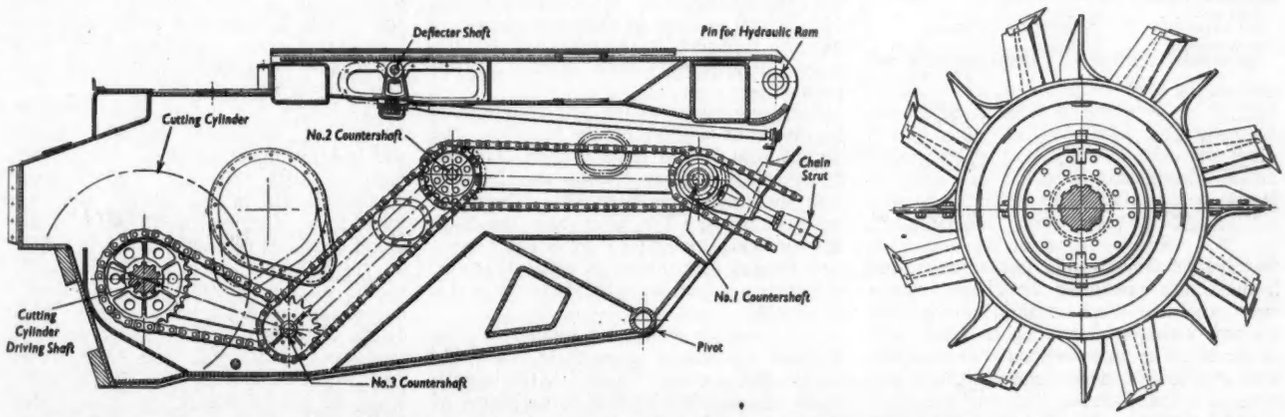



**General arrangement of the trench excavating machine, showing the excavating section at the front and the tracked section for engines and fuel behind. A cross section of the trench which the machine dug is also shown**

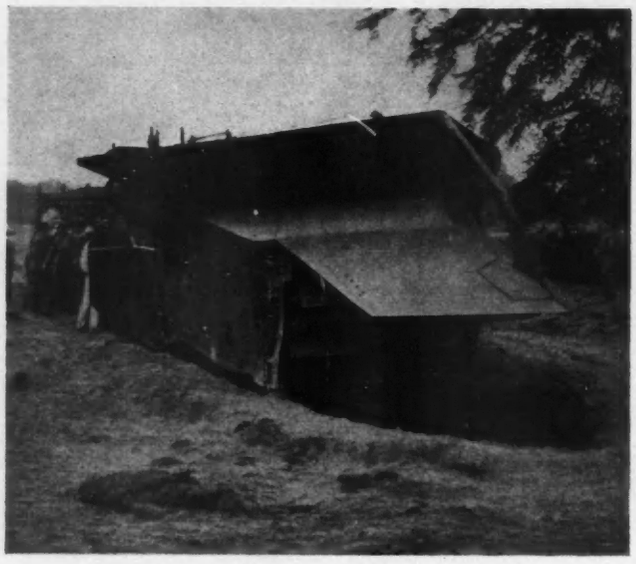
of sand. Having obtained the active support of the Chief of the Imperial General Staff, General Ironside, and other British military experts, I invited the Prime Minister and several of his colleagues to a demonstration. Later I took it over to France and exhibited it both to General Gamelin and later on to General Georges, who expressed approving interest. On December 6 I was assured that immediate orders and absolute priority would produce two hundred of these machines by March, 1941. At the same time it was suggested that a bigger machine might dig a trench wide enough for tanks.

"On February 7, 1940, Cabinet and Treasury approval were given for the construction of two hundred narrow 'infantry' and forty wide 'officer' machines. The design was so novel that trial units of the main components had first to be built. In April a hitch occurred, We had hitherto relied on a single Merlin-Marine type of engine, but now the Air Ministry wanted all these, and another heavier and larger engine had to be accepted instead. The machine in its final form weighed over a hundred tons, was seventy-seven feet long, and eight feet high. This mammoth mole could cut in loam a trench five feet deep and seven-and-a-half feet wide at half-a-mile an hour, involving the movement of eight thousand tons of soil. In March, 1940, the whole process of manufacture was transferred to a special department of the Ministry of Supply. The utmost secrecy was maintained by the three hundred and fifty firms involved in making the separate parts, or in assembling them at selected centres. Geological analysis was made of the soil of Northern France and Belgium, and several suitable areas were found where the machine could be used as part of a great offensive battle plan.

"But all this labour, requiring at every stage so many people to be convinced or persuaded, led to nothing. A very different form of warfare was soon to descend upon us like an avalanche, sweeping all before it. As will presently be seen, I lost no time in casting aside these elaborate plans and releasing the resources they involved. A few specimens alone were finished and preserved for some special tactical problem or for cutting emergency anti-tank obstacles.




**(Left) Detail of the chain drive to the cutting cylinder in the front section of the machine. (Right) The cutter wheel, showing alternate cutter blades and "throwers." At top-speed about 1·2in was the maximum cut at each revolution of the wheel**



(Left) The form of the plough, with the dual cutting cylinders below it, and the transverse conveyor behind it, are clearly shown. (Right) The starboard steering door is shown in the outward position. Note the cleanness of the excavated trench

By May, 1943, we had only the pilot model, four narrow and five wide machines, made or making. After seeing the full-sized pilot model perform with astonishing efficiency, I minuted 'cancel and wind up the four of the five "officer"-type, but keep the four "infantry"-type in good order. Their turn may come.' These survivors were kept in store until the summer of 1945, when the Siegfried line being pierced by other methods, all except one was dismantled. Such was the tale of 'Cultivator No. 6.' I am responsible but impenitent."

## Design and Construction of the Machine

The smaller, so-called "infantry" version of this trenching machine was indeed a formidable excavator. It dug at a rate comparable with, if not exceeding, that achieved by the largest present-day excavator, which has a 60 cubic yard bucket; but such comparison is not entirely just, for its purpose was quite different from normal excavators, and it was considered, to some extent, an expendable piece of equipment.

The "infantry" machine is shown in the accompanying illustrations, and some principal figures of dimensions and performance are listed in the table. It will be observed

*Dimensions and Performance of Trench Excavating Machine*

| | |
|---|---|
| **Dimensions in working order:** | |
| Length | 77ft |
| Breadth | 18ft 6in |
| Height | 10ft 2in |
| **Approximate weights:** | |
| Front section | 30 tons |
| Back section | 100 tons |
| Track pressure | 20 lb per sq. in |
| Digging speeds | 0·415 m.p.h. and 0·670 m.p.h. |
| **Surfacing speeds:** | |
| Forward | 3·045 m.p.h. |
| Reverse | 1·626 m.p.h. |
| Maximum gradient | 1 in 10 |
| Track centre | 4ft 3in |
| Engine speed | 1500 r.p.m. |
| Speed of cutting cylinders | 74 r.p.m. |
| **Chain speeds:** | |
| Main conveyors | 1070ft per min |
| Side conveyors | 1095ft per min |

that the machine was in two sections, the front section containing the digging equipment and the back section, which was tracked, containing the engines, fuel, and so forth. The two sections were coupled with a hinge-pin, chain strut and hydraulic ram.

The trench was dug in two stages. The upper part was pushed out to the sides by a plough, and the lower part excavated by rotary cutters, spoil from the cutters being carried by main and transverse conveyors and deposited clear of the heap of ploughed material. The digging speeds were 0·42 and 0·67 miles per hour; the cross-section of the trench shows clearly the scale of operation.

The main structure of the machine was of welded steel. The back section contained two 600 h.p. diesel engines, one providing power for propulsion and for the effort of the plough, and the other driving the rotary cutters. The back section could be dismantled into two parts for transport. The drive forward to the cutters was through a Wellman-Bibby torsional vibration damper and hydraulic coupling to a primary reduction gearbox. A chain drive was then taken to swinging gears, from which a chain passed from the back section to the first countershaft of the front section. Depth of cut was controlled by the pinned coupling and hydraulic jack between the two sections, and the swinging gears were introduced for that reason. The propulsion engine drove through a Bibby coupling and hydraulic coupling to a gearbox, and thence by two chain drives to the lantern pinions which turned the track sprockets.

When in operation, the depth of trench was controlled by operating the hydraulic cylinder. Steering was effected by swinging out a door and pressing it against the side of the trench with a hydraulic ram. Controls were concentrated in the conning tower. Nearly 600 gallons of fuel was carried, a quantity sufficient, it was estimated, for ten hours' digging with both engines at full power.

The chain drive to the first countershaft in the front section of the machine, the arrangement in the front section, and the design of the rotary cutters, can be seen from the drawing on page 397. The chain drive comprised a 3½in pitch chain, the chain centres being maintained by a chain strut consisting of forked ends in which the chain sprockets were carried in ball bearings, and a turnbuckle.

The front or excavating section of the machine comprised structurally, two side frames and a centre frame (all fabricated), connected together by four large beams of box section. The transmission chains were housed inside the centre frame, and the spaces on each side of it were taken up by two identical sets of excavating equipment, each including a rotary cutting cylinder, main conveyor and lateral conveyor.

Attention should be drawn to the high speed of the chains (see table); they were built to close tolerances and no method of adjustment was included for them. Their speed was such that spoil was thrown from the main conveyor on to the side conveyor. If the machine canted, a deflector plate could be lowered in the path of the spoil as it was thrown towards the side conveyor on the low side. It then dropped to the bottom of the trench to make a level base for the tracks of the back section.

The plough was bolted to the main frame of the front section. It was designed to cut to a depth of 2ft 6in and throw all the material clear, forming a trench 7ft wide at the bottom and 8ft wide at the top. The downward thrust due to the ploughing action was taken partly by the hydraulic cylinder between the two sections of the machine, and partly by a hydraulically-operated skid plate on the back of the plough. The front end of the skid plate was hinged to the plough, and its rear end controlled the plough through two hydraulic rams.

The cutting cylinders followed behind the plough, excavating the lower 2ft 6in depth and 7ft 6in width of trench. Vertical ploughs at each side frame and at the centre frame cut the sides of the lower trench and fed the cut material into the rotary cutters. The construction of these cutters is illustrated, and it will be seen that cutter blades and "throwers" were spaced alternately round the cylinder. The teeth—of hardened steel—were renewable.

The design and construction of such a novel and large-scale machine brought with it many difficult problems. Although the machine itself was not needed, several detailed points in the design work were found to be of general worth and have since found considerable application. In particular, the hydraulic system and the lubrication of the machine enabled some advance to be made in these fields, we understand. Novel details of the work also included soil shear tests with the track plate teeth, to ensure that they would not shear the trench bottom when the plough was in operation. Much of the actual work of design and construction was carried out under adverse wartime

conditions, including air attacks on some of the establishments concerned in the manufacturing work. In test runs, the machine successfully penetrated barbed wire barriers and a minefield, the mines being turned over and not exploding.

Indication has already been given in the passage reproduced from Sir Winston's war memoirs of some of the principal personalities and firms concerned in the development of "Cultivator No. 6," but a more comprehensive list of the firms involved, as far as can be ascertained after fifteen years, is given here in conclusion. The design was carried out by a special department under the Ministry of Supply designated the N.L.E. department (Naval Land Equipment) built up from the staff of the Directorate of Naval Construction, and from Ruston-Bucyrus, Ltd., including that firm's chief engineer, Mr. W. Savage. Hence the machine became known as "Nellie." The main firm for the construction of the machine was Ruston-Bucyrus, Ltd. The engines were supplied by Davey, Paxman and Co., Ltd.; radiators, Serck Radiators, Ltd.; forward gearbox, Bostock and Bramley, Ltd.; rear gearbox, Turbine Gears, Ltd.; chain drives, Renold Chains, Ltd.; Vulcan-Sinclair fluid couplings, Fluidrive Engineering Co., Ltd.; the plough, J. and H. McLaren, Ltd.; steel castings, F. H. Lloyd & Co., Ltd.; anti-friction bearings, Ransome & Marles Bearing Co., Ltd.; non-ferrous castings, Yorkshire Engineering Supplies, Ltd.; soil shear tests; N.L.E. department; structural work, Joseph Westwood & Co., Ltd.

The photographs reproduced are from the collection at the Imperial War Museum.

# Engineering and Shipbuilding Wages

AT the end of last October, the Confederation of Shipbuilding and Engineering Unions presented to the Engineering and Allied Employers' National Federation a claim for a 10 per cent increase in the wages of workers in the engineering industry. A demand, in similar terms, was also submitted to the Shipbuilding Employers' Federation on behalf of workers in the shipbuilding and ship repairing industry. The claims have been fully considered by the two employers' federations, which have now stated that they are not able to meet the demands made.

The Shipbuilding Employers' Federation announced its final rejection of the claim on Tuesday of last week. It acknowledged that, at present, shipbuilders' order books were full, but emphasised that that position was one which could be maintained only if there was no increase in costs; any marked rise in steel prices or in labour costs could quickly alter the situation. Last Tuesday, the Engineering and Allied Employers' National Federation met representatives of the union confederation, who were informed that the demand for a 10 per cent wage increase in the engineering industries could not be granted.

The Federation's director, Mr. Macarty, pointed out that if wages in the engineering industry were increased when productivity was falling, a rise in prices was inevitable, thus adding to inflation at home and to the difficulty of selling overseas. To that, the president of the Federation, Mr. F. C. Braby, added that wages must not be allowed to outrun productivity. The country, he said, must improve its export position, which meant that export prices must be reduced and not increased.

It is useful to record the history of this latest 10 per cent wage claim put forward for shipbuilding and engineering workers. In many respects it follows the pattern of claims which have been advanced nearly every year since the end of the war. In March last year, wage increases were granted to adult male workers of 12s. 6d. a week for skilled men, 11s. for intermediate grades, and 9s. 6d. for unskilled men. Agreement on these amounts was reached after five months of negotiations following a claim for a 15 per cent increase. The increases granted represented approximately an 8 per cent addition to the then existing rates, and were virtually the same for the shipbuilding and engineering industries. At the end of April, the Amalgamated Engineering Union's national committee held its annual conference, at which unanimous approval was given to a resolution calling for a "substantial wage increase." A few weeks later, the Engineering and Allied Employers' National Federation announced that its management board had decided that further wage demands from the unions would be rejected. That decision, it was explained, was taken in view of the national inflationary position, and in view of the fact that a wage increase was granted last March.

The demand which was initiated by the A.E.U. at the end of April, however, was given further emphasis during August at the annual conference of the Confederation of Shipbuilding and Engineering Unions. There, a resolution on wages was proposed, by Mr. R. Openshaw, president of the A.E.U. and the Confederation's executive was directed to make "an immediate application for a substantial wage increase for all manual workers in the shipbuilding and engineering industries." During the debate on wages, it was urged that no trade union could agree to refrain from attempts to improve the living standards of its members when other people were improving theirs, and it was also claimed that higher wages would be an incentive to greater efficiency. In the resolution passed at the union confederation's conference, no specific figure was mentioned, but when the claim was formulated by the executive the amount asked for was 10 per cent. The Trades Union Congress met during the first week of September, and a resolution which was carried by a large majority was one which rejected any proposals "to recover control of the economic situation by wage restraint." The terms of that resolution had been endorsed by all the big unions, and before the end of October the Confederation of Shipbuilding and Engineering Unions had formally submitted its demands for a 10 per cent wage increase to the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation respectively. It is these demands which have now been refused.

A few days before the claims were lodged last October, the British Employers' Confederation published a statement on the subject of wage claims generally. It pointed out that in industry as a whole wages were the largest single element in costs, and that a general increase in wages at the present time would be self-defeating, as it would induce a further rise in prices. This statement added that between 1950 and 1955 average labour costs per unit of output in the United Kingdom rose by 29 per cent; in the U.S.A., by 10 per cent; and in Western Germany by only 2 per cent. Further wage increases in the present circumstances, the British Employers' Confederation said, would still worsen that position, and higher earnings could only be justified where they did not increase the cost of goods or services.

At the time of going to press, the situation at the rejection of the shipbuilding and engineering wage claims is not reassuring. On Thursday of last week, the executive of the Confederation of Shipbuilding and Engineering Unions met to consider the refusal of the shipbuilding demand. A resolution was passed recommending the executives of the unions concerned to advise their members to cease work as from midday on Saturday, March 16. The resolution said that the Confederation's executive committee had been forced into this position by the "blunt refusal of the Shipbuilding Employers' Federation, in conditions of unequalled prosperity, to consider any advance in wages." The union Confederation's executive met again on Tuesday afternoon to consider the situation in the engineering industry in the light of the employers' rejection of that claim. It decided to call a meeting of the executives of the affiliated unions to be held this (Friday) afternoon at which details of the action recommended are to be made known.

The Minister of Labour, Mr. Iain Macleod, made a statement in the House of Commons on Tuesday, during which he announced that Lord Evershed, Master of the Rolls, had agreed to act as arbitrator in the shipbuilding wage dispute. Mr. Macleod said he had reached the conclusion that, in the circumstances of this dispute, something other than the normal conciliation action by his department was required. Equally, he added, his view was that the issue was not appropriate for examination by a court of inquiry or other body, as the causes of the dispute were clear. Nevertheless, the Minister emphasised, a settlement must be reached, and obviously everything should be done to bring that about without plunging the shipbuilding industry into a disastrous strike. A peaceful settlement of the dispute, he felt, could be found by resort to arbitration by a completely impartial person, and with that in mind he had secured Lord Evershed's agreement to act. The Minister stated that he and his officers were ready and willing to meet representatives of the employers and the unions to give them any further information about the proposal, or to discuss with them any other aspects of the situation.

Up till our time of printing, however, the union leaders concerned were insisting that arbitration would serve no useful purpose. What the union members wanted, it was stressed, was a settlement in "hard cash."

## "Mechanicals" Summer Meeting

THIS year's summer meeting of the Institution of Mechanical Engineers is to be held in Cambridge on Wednesday, Thursday and Friday, July 10, 11 and 12. Members from overseas who will be in this country at the time of the meeting and who wish to attend are asked to notify the Secretary of the Institution as soon as possible. On the same three days, July 10, 11 and 12, at 1, Birdcage Walk, Westminster, London, S.W.1, there is to be held a conference on "Thermodynamic and Transport Properties of Fluids." This conference is being sponsored jointly by the Institution of Mechanical Engineers and the International Union of Pure and Applied Chemistry; detailed arrangements are to be announced shortly.

# Harvesting Machinery for Brown Sub-littoral Seaweeds

By PHILIP JACKSON, M.Sc., M.I.Mech.E., M.I.Chem.E., F.R.S.E. *

No. I

*Articles on the harvesting of seaweed were published in this journal in* 1947 *and* 1952. *Until recently the research work was done by the Institute of Seaweed Research under Government sponsorship. That sponsorship has now been brought to an end. In this article the author reviews the progress made with two systems of harvesting, one in which the plants are torn by hooks from the sea bed and mechanically elevated to the surface, the other in which the plants are severed from the sea bed and lifted to the surface by entrainment in water. He suggests that both systems are sufficiently advanced for private industry to undertake further development, and indicates directions in which further progress could be made.*

GOVERNMENT-SPONSORED research into the harvesting of sub-littoral (under water) seaweed has now been brought to a close, and it is therefore appropriate to review the progress that has been made in this field and to indicate the most promising lines to follow in further development.

The industry based on seaweed in this country at present uses cast seaweed collected from the beaches and/or littoral (intertidal) seaweed, hand cut from exposed rocks at low tide. These sources apparently satisfy current requirements, but the uncertainties of the former and the relatively small total quantity of the latter[1] impose limitations on future development. Also, it has recently been shown that harvesting direct from the sea bed is cheaper than collecting cast seaweed.

In America mechanical harvesters are used off the Pacific coast, but the species of seaweed being harvested differ from those found in our own coastal waters in that they are buoyant and visible on the surface of the water. In these circumstances harvesting is relatively simple, and machines operating on the broad principle of cutting the algæ a few feet below the surface and allowing it to float on to a partially submerged conveyor communicating with the holds of the harvesting ship can collect as much as 250 wet tons per day. On the eastern seaboard the predominating species are those common to the sub-littoral zones of Britain, Norway, France and Ireland, viz. *Laminaria cloustoni*, *L. digitata* and *L. saccharina*, which can only be harvested by machinery operating on the sea bed. Although two machines have been devised for the collection of these species by Clark[2] and Knowlton, Doucette and Eager,[3] they are not suitable, and probably not intended, for commercial use.

A suitable machine has, however, now been devised and developed in this country and proved to be effective, mechanically reliable, and economic in continuous operation over long periods at sea. Essentially this machine comprises a continuous system of hooks arranged to tear the plants from the sea bed and elevate them to the surface. A second machine, operating on the principle of severing the plants from the sea bed and transporting them to the surface by entrainment in water, is at an advanced stage of development.

## The Belt Harvester

*Evolution of the Belt System.*—Experiments were commenced in 1946 with specially designed grapnels operated intermittently from small boats to prove that it was possible to utilise the pronounced draping properties of sub-littoral seaweed in a system of harvesting.[4] By 1947 a technique had been developed for harvesting based on this principle. The primary drawback was the relatively long, ineffective period (lowering, raising and unloading), compared with the net time occupied in dislodging the algæ from the sea bed, and it was obvious that the only satisfactory way of meeting the demands of industry at a reasonable cost was by means of a continuous mechanised system. Nevertheless, these experiments provided valuable experience in sea bed operations and a considerable amount of data for the design of such a system.

The original conception of a continuous mechanical harvester operating on this principle envisaged an endless power-driven chain carrying grapnels or rows of hooks with supporting skids to maintain them in an upright position and to assist in negotiating obstacles on the sea bed. Preliminary tests on a short length of chain with a single row of hooks proved that the system had a high harvesting efficiency,[5] but that it was impractical because of the weight factor. This was primarily due to the length of hook required to provide a sufficiently firm grip of the draped algæ to overcome its resistance to dislodgement. Any reduction in this length which significantly reduced the moments of the forces acting on the hooks therefore reduced their effectiveness. This led to an alternative system which relied for its successful operation on two novel features,[6] namely, the use of a mesh belt to compact the algæ into a tangled mass in front of the hooks, and operation of the hooks attached to the belt in a rearward direction on the sea bed relative to the direction of the ship.

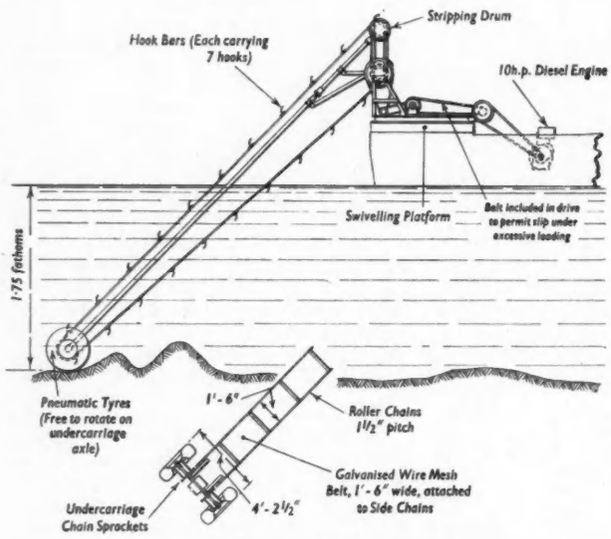

Stripping Drum
Hook Bars (Each carrying 7 hooks)
10h.p. Diesel Engine
Swivelling Platform
Belt included in drive to permit slip under excessive loading
1·75 fathoms
Pneumatic Tyres (Free to rotate on undercarriage axle)
1'-6"
Roller Chains 1½" pitch
Galvanised Wire Mesh Belt, 1'-6" wide, attached to Side Chains
Undercarriage Chain Sprockets
4'-2½"

**Fig. 1—Small experimental belt harvester**

The first experiments to assess the compacting principle, using a short test section, gave results sufficiently encouraging to justify the construction of a small manually operated belt harvester (Fig. 1). This machine was operated in sheltered sea areas until sufficient experience had been gained and enough data collected to calculate the power requirements at various speeds. A mechanical drive was then incorporated and operations commenced to assess the efficacy of the system. By the end of 1949 the operating principles had been proved in runs of short duration during periods of calm surface conditions,[6] and it remained only to develop the system for continuous long-term operation under the more severe conditions of commercial harvesting.

*Large Experimental Unit.*—It was impossible, within the limitations of the small unit referred to above, to investigate many of the problems in the practical application of this system of harvesting and, for the final stages of development, a more appropriately constructed machine was fitted to a 50ft motor fishing vessel, powered by an 88 h.p. Perkins marine diesel engine. The first series of tests were aimed at identifying and systematically eliminating mechanical and other weaknesses and the appropriately modified unit was ready for final reliability, capacity and efficiency trials by the middle of 1954. The arrangement of the unit at this stage is shown in Fig. 2. The principle of operation was essentially unchanged, but the belt drum centres were increased and the relevant parts appropriately redesigned to increase the maximum harvesting depth to 3½ fathoms and to eliminate the mechanical weaknesses revealed during the initial tests. In addition, the layout was altered to facilitate handling at sea between the stowed and operating positions.

In the operating position the driving or delivery end was carried outboard on a retracting platform *A* situated as far forward as the curvature of the bows would permit with the undercarriage resting on the sea bed on pneumatic-tyred wheels *B*, free to rotate on the axle *C* of the undercarriage assembly. This axle also carried flanged drums *D* around which the belt *E* ran. The direction of motion of the belt was downwards in the lower run so that the hooks *F* engaged the compacted plants with a downward and backward motion. Compacting was effected by steel mesh *G* stretched between the two side chains *H* of the main belt assembly. To permit the undercarriage to follow the contour of the sea bed, the main frame was arranged to pivot about the lower driving shaft *I*. This shaft was carried in a driving platform, comprising two bearing pedestals *J* welded to a base frame *K* mounted at the outer end of the retracting platform *A*. The driving platform was pivoted on the retracting platform, but was secured to it during harvesting operations by means of swing bolts.

When stowing the harvester the undercarriage end was raised to deck level by

* Until recently deputy director of the Institute of Seaweed Research—now in private practice as a consultant.

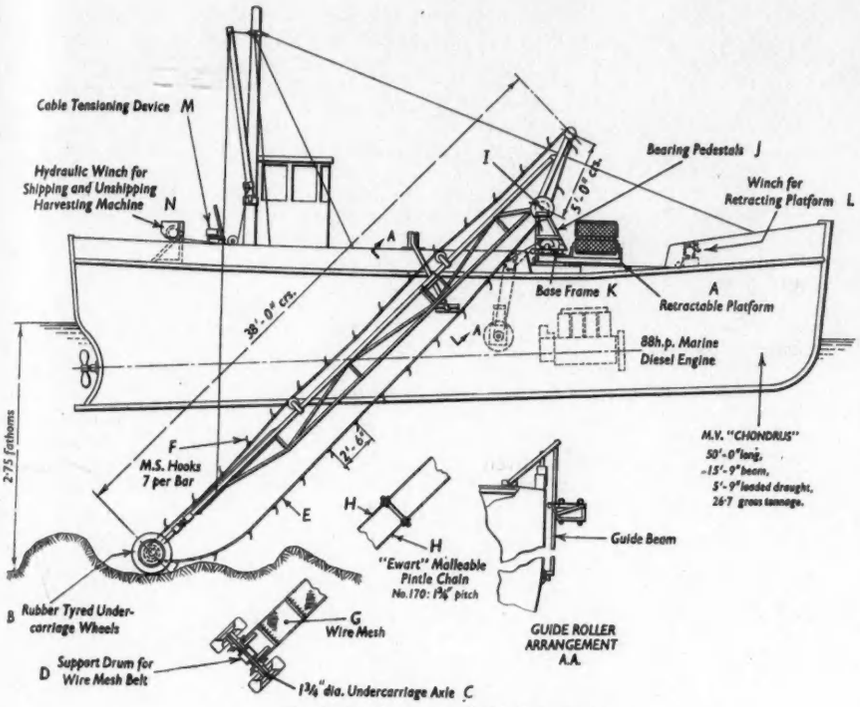

Cable Tensioning Device M
Hydraulic Winch for Shipping and Unshipping Harvesting Machine N
Bearing Pedestals J
Winch for Retracting Platform L
Base Frame K
A Retractable Platform
88h.p. Marine Diesel Engine
38'-0" crs.
2·75 fathoms
F M.S. Hooks 7 per Bar
E
H
"Ewart" Malleable Pintle Chain No.170: 1¾" pitch
Guide Beam
M.V. "CHONDRUS" 50'-0" long, 15'-9" beam, 5'-9" loaded draught, 26·7 gross tonnage.
B Rubber Tyred Undercarriage Wheels
G Wire Mesh
D Support Drum for Wire Mesh Belt
1¾" dia. Undercarriage Axle C
GUIDE ROLLER ARRANGEMENT A.A.

Fig. 2—Large experimental belt harvester

means of the derrick situated aft of the wheelhouse, the swing bolts released at the driving platform and the bolts locking the retracting platform to the deck removed. The retracting platform was then winched inboard, *L*, and the aft end simultaneously brought in and lowered on to a beam bolted across the stern.

The drive, provided by an existing standard 30 h.p. petrol-paraffin engine (although the power absorbed did not exceed 5 h.p.), was transmitted through a hand-operated Renold chain clutch and a spring-loaded Ferodo disc overload slipping clutch to the lower and upper driving shafts in that order.

Undercarriage axle movement due to relative movement between the wheels as one or other rose independently to surmount obstacles was accommodated by the structural flexibility of the machine; excessive lateral deflection was prevented by a guide roller arrangement (Fig. 2), which constrained the main frame to vertical movement only, and the transmission of forces acting on the undercarriage to the main frame was minimised by spring loading the undercarriage wheels (Fig. 5) to give a cushioning effect. Damage generally was minimised by virtue of the backward motion of the hooks relative to the ship and the overload slipping clutch incorporated in the drive. To prevent the undercarriage lifting cable fouling the hooks when negotiating a sudden rise on the sea bed, a hydraulic cable tensioning device *M* (Fig. 2) was incorporated in the winch drive *N*. See also Fig. 3.

*Final Tests with Large Unit.*—In the final tests the unit was operated continuously at sea for long periods in ten different areas and under commercial harvesting conditions, to assess its mechanical reliability, capacity and harvesting efficiency, and to study the economics of harvesting by this method. The results of these tests, which have been reported in detail elsewhere,[7] are summarised in Figs. 4 and 6.

The mean mechanical reliability, defined as the ratio of actual to available operating times or the availability of the machine, over a period of 368 hours was found to be 91·5 per cent (Fig. 4), with a standard deviation $\hat{s}$ of 7. This represents about thirty-one hours of available operating time lost due to mechanical failure and compares very favourably with the performance of earth-moving, agricultural, mining and peat-cutting machinery. It will be seen from Fig. 6 that the mean harvesting rate in areas of prolific growth was 3 tons per hour (Yinstay Bay, Orkney) and 3·3 tons per hour (Papa Sound, Westray) over periods of about twenty-five hours and eleven hours, respectively. In exceptionally dense patches of seaweed in these areas the maximum capacity recorded was nearly 12 tons per hour. Further increase in machine capacity would therefore have only a relatively small overall effect on the mean harvesting rate, which could only be significantly increased by covering a greater area in a given time. Efficiency, expressed as the ratio of the weight of seaweed harvested to the weight growing on the area covered by the machine on the sea bed, varied between 0·80 and 0·90, with the mean probably nearer to the latter value.

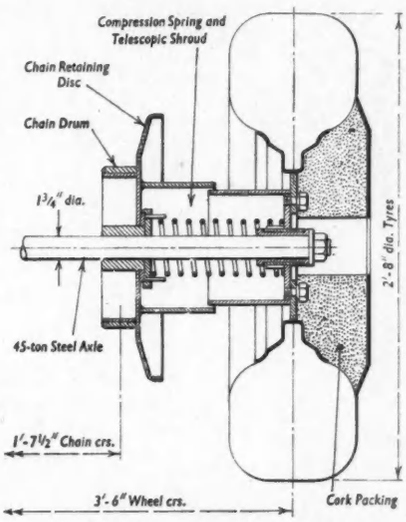



Fig. 5—Undercarriage wheel assembly

A machine of the kind shown in Fig. 2, but with an additional and similar machine fitted to the port side of the ship, operating

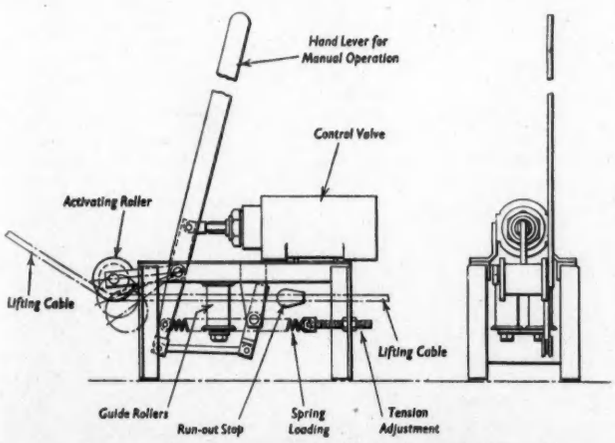



Fig. 3—Winch operating and cable tensioning device

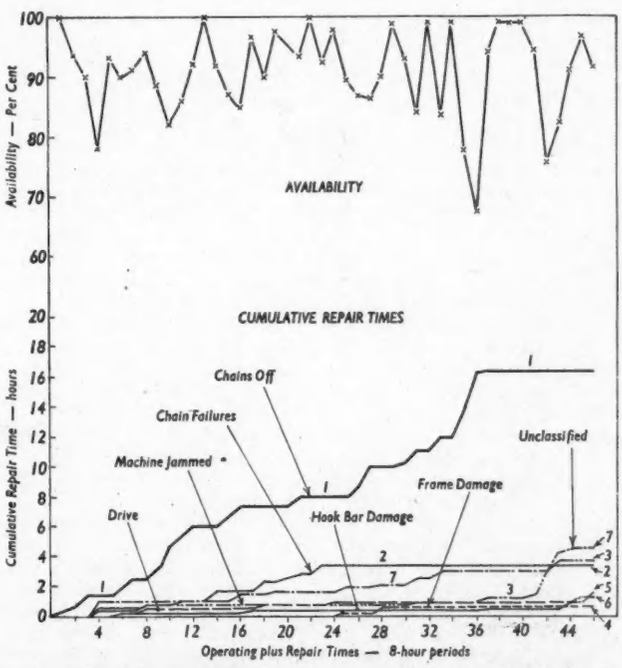



Fig. 4—Reliability of belt harvester and analysis of mechanical failures

in an area of prolific growth, would harvest about 32 tons of wet seaweed per day (assuming the harvesting site is within half an hour's mean "steaming" time of the landing point) at a cost of approximately 19s. per wet ton landed.

*Conclusions and Suggestions for Further Development of the Belt Harvester.*—A machine has been devised and proved suitable for the continuous harvesting of sub-littoral seaweed of the species *Laminaria cloustoni*, *L. digitata* and *L. saccharina*. The final machine has been evolved gradually and, to obviate the risk of incurring avoidable expense and wasting time, modifications and additions have been effected in the simplest possible manner. In these circumstances, it is only to be expected that certain design features would not be repeated in subsequent machines. The principal features in this category are (1) the somewhat heavy supporting structure, (2) the use of the lower driving shaft as the pivot for the main frame, thereby significantly increasing the load on it, (3) the present drive which could with advantage be replaced by a hydraulic system to give smoother operation and more deck space, (4) the arrangement of buoyancy tanks controlling the pressure on the sea bed, and (5)

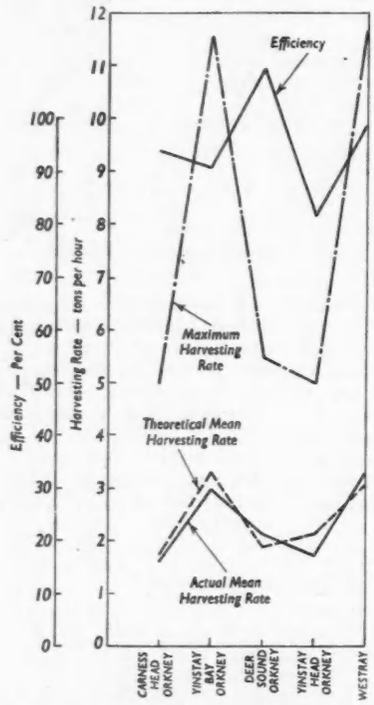



**Fig. 6—Harvesting capacity and efficiency of the experimental belt harvester**

the lack of precautions against seaweed loss from the stripping end when operating in high winds, which could be simply remedied by appropriately placed shields.

It is worth while investigating the possibility of still further increasing the capacity of the machine to reduce the cost per ton of seaweed and the size and capital cost of the fleet of ships required. Two promising lines of investigation are the possibility of increasing the effective width of the belt and the development of a modified arrangement in which the hooks are operated on the sea bed in a direction roughly at right angles to that of the ship. The former requires no further comment. The importance of the latter stems from the fact that the capacity of the present system is limited by the minimum effective pitch of hook bars, below which succeeding rows of hooks reach the sea bed before the machine has moved forward sufficiently to run out of that portion of the track cleared by the preceding hooks. By operating the belt roughly parallel to the beam of the ship, forward movement approximately equal to the belt width would ensure succeeding hooks reaching the sea bed on a fresh track and so permit a significant reduction in effective pitch. Many practical difficulties would be encountered in attempting these modifications, but provided they can be overcome it is reasonable to assume that the capacity could be considerably increased and the operating and capital costs proportionately reduced.

The logical next stage is the investigation of the problem of transporting the harvest to the landing point, a problem common to all systems of harvesting. The carrying capacity of a harvesting ship can be approximately doubled by passing the seaweed through a pulveriser before depositing it in the holds, but even then is unlikely to exceed 10 tons. This is inadequate for economic operation except when relatively short distances are involved. Transferring the harvest at sea to separate transport ships may be difficult under the hazardous operating conditions in areas of profilic growth during periods of bad weather, but given reasonably good surface conditions this is perhaps the most promising method of transport for relatively long distances. Because of the low capital expenditure involved it is, however, worth while examining also the possibility of discharging the harvest direct into nets which, when full, could be quickly and easily detached and left with marker buoys for subsequent collection.

Now that a satisfactory harvesting machine has been evolved and proved, it should be a relatively simple matter to effect improvements on the lines suggested above and to solve the extraneous problems (transporting, off-loading, &c.) associated with its use.

## The Suction Harvester

*Original Investigations.*—The cutting and entrainment system of harvesting was first investigated towards the end of 1944, when the Ministry of Supply required calcium alginate from seaweed for use in the manufacture of camouflage materials. The machine used experimentally at that time comprised essentially rotating cutters carried in a tubular structure designed for dragging along the sea bed, and shrouded by the inlet of an entrainment system which terminated on the deck of the surface craft. This investigation has been described by Mackenzie[8] and the results reviewed by Jackson.[4] Briefly, the machine was found to be unsuitable because of repeated mechanical failure, jamming of the cutters, and the very low seaweed-water concentration in the entrainment system. The investigation of these problems was complicated by operating the machine as a complete unit under actual harvesting conditions. In these circumstances it was, for example, impossible to determine whether the low seaweed-water concentration was attributable to the cutting or entrainment systems. It was therefore decided to investigate the two systems separately.

*Cutting.*—Several different forms of cutter were considered.[4] These included rotating knives, reciprocating knives of the type used in agricultural machinery, toothed discs in contact with finger plates or counter rotating discs, band saws, reciprocating saw blades, revolving high-tensile steel wires between synchronised rotating discs, and a modified propeller pump with cutting blades in a vertical plane. Of these the reciprocating agricultural knives appeared to be the most suitable, because of simplicity, relatively low operating speed, limited movement and robust construction. Comprehensive tests[9] were carried out with this form of cutter mounted at the leading edge of an experimental trawl, with the objects of eliminating faults in the mechanism, devising an effective means of protecting the blades against damage, and seaweed draping, and determining the capacity and most effective ship-blade speed ratio.

The final arrangement was found to be effective, mechanically reliable and reasonably efficient. The average cutting efficiency factor was 0·60 and the capacity 1·7 to 3·3 tons per hour per foot of effective cutting width, depending on the density of seaweed growth in the test areas. The cutting efficiency factor tended to increase with decrease in ship-blade speed ratio, the limiting factor being the lowest speed at which steerage of the ship could be maintained.

*Entrainment.*—Concurrently with the investigation described above, the problems in entraining seaweed were investigated in an experimental suction system mounted on a jetty with a straight drop into 3 to 4 fathoms of water, and a satisfactory system was developed and proved to be effective under the test conditions. This system has been described in a previous publication.[10] Two types of pump were used: (1) a jet type with an annular port in place of the more conventional centre jet, giving an obstruction-free passage through the body of the pump, and (2) a volute type centrifugal with a two-passage, full-area unchokeable impeller. Both pumps passed the seaweed-water mixture without blockage. The jet pump had, as would be expected, a much lower hydraulic efficiency than the centrifugal pump, but the latter damaged the seaweed, with consequent increase in the rate of bacterial decomposition during subsequent wet storage. If the seaweed is processed within a reasonably short time of harvesting, however, or if some alternative economic means of preservation can be devised, then the centrifugal pump is the obvious choice for this duty.

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(*To be continued*)

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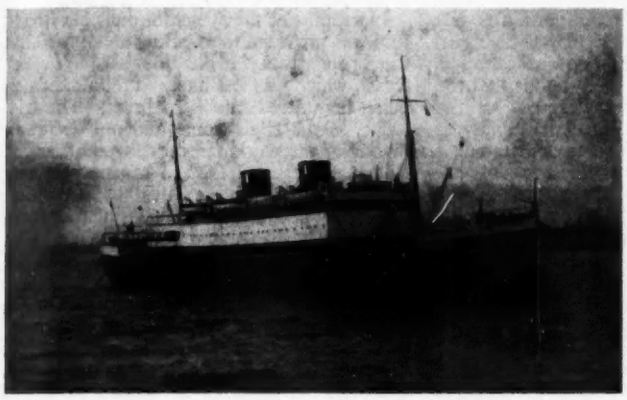
ALUMINIUM-TIN BEARINGS.—The *Quarterly Journal of the Tin Research Institute*, No. 37, includes a report on practical trials of aluminium-tin bearings. Three alloys were used, namely, the T.R.I. alloy, containing 21·1 per cent of tin, developed by the Tin Research Institute; "Lubral," containing 6·55 per cent of tin, developed by the Instituto Sperimentale Metalli Leggeri; and an alloy containing 6·61 per cent of tin and 0·88 (average) of titanium, developed by N. Collari and L. Paglialunga. The bearings were supplied to the Rome tramways for testing and were run as axle bearings, over a distance of 100,000km, with a specified loading of 25 kg per square centimetre and a rubbing velocity of 2·3m per second. Examination showed that the bearings had not suffered any damage and that there was no sign of deformation or of seizing, while the maximum wear measured was 0·6mm.

# Motor Ship "Scottish Coast"

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

FOR many years cross-channel services were operated by paddle steamers, but in the early 'seventies twinscrew steamers began to be used on the longer passages, and in 1903 the turbine steamer "The Queen" was built for the South Eastern and Chatham Railway. She was the first cross-channel turbine steamer in the world, and from that date to the present the turbine steamer has held its own for this class of work. However, in 1929 a very definite rival appeared when the Belfast Steamship Company brought into service for the sailings between Liverpool and Belfast three large



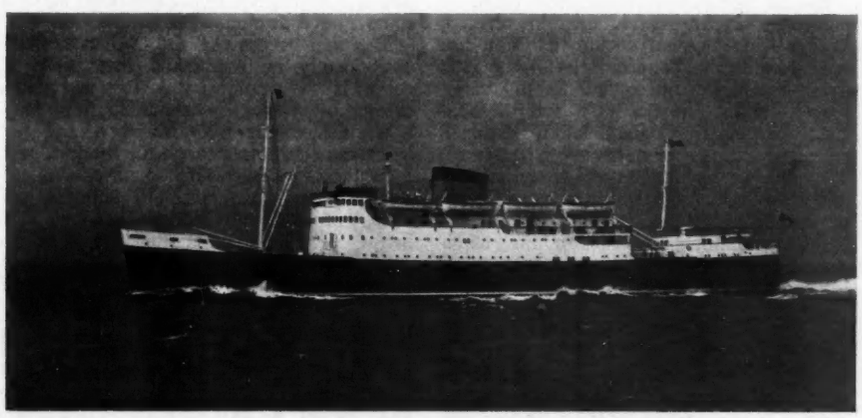
Motor ship "Ulster Monarch," 1929, one of the first cross-channel motor vessels

motor vessels "Ulster Prince," "Ulster Monarch" (illustrated) and "Ulster Queen" all built by Harland and Wolff, and having the following principal dimensions: length, 346·0ft; breadth, 46·2ft; depth, 15·2ft; tonnage 3757 gross. Driven by diesel engines, each engine having ten cylinders 24·8in diameter by 38·56in stroke, at 100 r.p.m., a speed of 18½ knots was obtained. The chief drawback to these early motor ships was vibration, which has since in measure been overcome. The owners were so satisfied with these vessels that no reversion to steam has yet taken place.

When Coast Lines, Ltd., recently decided that a new cargo vessel was now required for the Irish passenger and cargo services—they now control the Belfast Steamship Company, the British and Irish Steam Packet Company, and other lines—an order was placed with Harland and Wolff, Belfast for a modern motor vessel. The name selected for her is "Scottish Coast," and she is illustrated here. Her principal dimensions are as follows: length, overall, 342ft 3in, between perpendiculars, 324ft; breadth, moulded, 51ft 6in; depth, moulded, 19ft 9in; tonnage, 3900 gross. The vessel is built on conventional lines with a raked and rounded stem, cruiser stern, two masts and a streamlined funnel. Two decks extend the length of the ship, containing most of the passenger accommodation, while a lower deck is situated fore and aft of the machinery space. In addition there are shorter decks known as bridge, sun, and promenade. On the sun deck is a combined cocktail bar and smoke room, which is partly recessed into the funnel. To what strange uses is the funnel of a modern vessel adapted! On the promenade deck is a smoke room, while there is a spacious and comfortable lounge on "A" deck, and on "B" deck is the dining saloon which can seat eighty-two persons, and is adjoining the entrance hall where is situated the ticket office. The foregoing saloons are for first-class passengers, for 246 of which sleeping accommodation is provided on the promenade, "A," and "B" decks in single-berth, double-berth and one four-berth cabins, all fitted with cot beds, basins with hot and cold fresh water and ventilation on the twin trunk Punkah Louvre system. Two special state rooms, each with two beds, dressing table, easy chairs, and private bath room and lavatory are found on "A" deck. The second-class accommodation is of a high standard and has sleeping accommodation for 144 persons in two-berth and four-berth cabins, while there are also ladies' and gentlemen's large sleeping cabins. There is a restaurant, smoke room, a large general room, and a ladies' room. Such is a brief description of the provision made for passengers, which is all of a high standard, the decorations being very pleasing. On S2 passenger certificate 250 first-class and 500 second-class can be carried, while on L.S.2 550 first-class and 650 second-class can be taken. The crew number sixty-eight. Air filters are fitted to the ventilation units throughout the vessel. No. 1 hold and No. 1 'tween decks are arranged for general cargo, No. 2 hold for insulated cargo, while the 'tween decks are arranged for the carriage of livestock or cargo. The cargo is handled by derricks and electric winches. The hull is divided into twelve watertight compartments by eleven bulkheads. A double bottom is suitably divided for fresh water, water ballast, oil fuel under Nos. 1, 2 and 3 holds and the machinery spaces, while the forward and after peaks and a large trimming tank forward are for water ballast. There is an oil fuel tank in the shaft tunnel.

The propelling machinery consists of two trunk type, airless injection, Harland-B. and W. diesel engines working on the two-stroke cycle, each having ten cylinders with diameters of 500mm and a stroke of 900mm, running at a speed of 155 r.p.m. The crank-pins and webs are of forged steel, and the bedplate is of welded steel. The thrust block is incorporated in the aft end of the bedplate. The pistons are cooled with oil from forced lubrication, while fresh water is used for cooling the cylinder liners, covers, and exhaust valves, and the lower parts of the cylinder liners are kept cool by the scavenge air, which is supplied by a pair of positive rotary blowers mounted on the back of each engine and driven by gears from the crankshaft. The engines are started up by compressed air stored in three receivers, two having a capacity of 332 and one of 420 cubic feet at a pressure of 25 atmospheres. The receivers are charged by two three-cylinder, two-stage 240 by 210/160 air compressors, one of which is a stand-by, each having a capacity of 240 cubic feet per hour. The propellers are of manganese bronze and are three bladed, the blades being solid with the boss, and provided with cones and sealing glands. The exhausts from the main engines are led to separate silencers situated in the funnel.

The engine-room and deck auxiliaries are all electrically driven, current being supplied by three diesel engine generator sets of Harland and Wolff make, each engine having six cylinders with a diameter of 316mm and a stroke of 420mm; they are of the four-cycle type and develop 250kW when running at 350 r.p.m. There are two main fresh water coolers, one for each engine, and one lubricating oil cooler. One triplex filter is fitted for the lubricating oil to serve both engines; centrifugal purifiers, electrically driven, are installed for fuel and lubricating oils. The electrical installation is carried out on the double wired system of 220V d.c., current being supplied through a main switch-board, the generators being arranged for parallel operation. There is provided an emergency diesel driven generating set of 40kW capacity at 220V d.c., complete with a lead-acid type emergency battery having a capacity of 104Ah, this battery being so arranged that it will switch over automatically to emergency lighting and watertight door circuits in the event of failure of the main supply. The main and emergency switch-boards are of Harland and Wolff construction, and are of the open fabricated type with sindanyo panels. There is a system of pre-



Motor ship "Scottish Coast" on her trials February, 1957

ference tripping for the main feeder circuits. Distribution is effected from the main switchboard through a number of master boards, each of the circuits being protected by circuit breakers where the current is above 200A, and by fuses when it is 200A and under. The engine-room and generator room are ventilated by four electrically driven fans, and electrical operation is applied to galley and pantry equipment, as well as to the steering gear for the streamlined rudder aft, this being of electric-hydraulic type. Incidentally, a bow rudder is available for use when going astern. Low voltage is supplied by two 24V nickel cadmium alkaline batteries with charging board so arranged to enable one battery to be on charge while the other is discharging, the low voltage being supplied for a luminous call system which is fitted throughout the first-class accommodation, call bells, loud speaking telephones, &c. Convector electrical heaters are provided in the entrances, first-class rooms, state rooms, officers', engineers' and crew's accommodation. The six electrically operated doors are controlled from the navigating bridge, and indicators are provided to show when these watertight doors are closed.

A Spanner oil-fired boiler, manufactured by Harland and Wolff, Ltd., generates steam at a pressure of 100 lb per square inch. The steam so supplied is used both for heating and cooking. The oil-burning installation works on the low pressure air system, and two Weir feed pumps, each with a capacity of 4000 lb per hour, supply fresh water to the boiler.

A corner of the cocktail bar in the "Scottish Coast"

Special precautions have been taken to guard against the risk of fire, for which a Walter Kidde system of fire detection has been installed in connection with the $CO_2$ system of fire extinguishing for all cargo spaces, while for the first and second-class passenger accommodation Grinnell sprinkler extinguishing has been provided. The life saving appliances comprise five 28ft lifeboats, two of a length of 26ft, and one of 28ft length which is motor driven, all being of aluminium construction, fitted under gravity davits; provision has been made to accommodate in all 1200 passengers.

To minimise rolling in a seaway the vessel has been furnished with Denny-Brown stabilisers. As an example of how space has been utilised it might be mentioned that on the port side of the tunnel space the engineers' store is located, while on the starboard side there is to be found a useful workshop.

The most up-to-date navigational aids have been supplied including wireless, radar, direction finder, and echo sounding equipment.

"Scottish Coast" was launched in August 1956, by Lady Glentoran, wife of the Minister of Commerce for Northern Ireland, underwent her acceptance trials in the Irish Sea and Firth of Clyde on February 27 and 28, and left Belfast for Liverpool on March 5. It is estimated she will cover some 45,000 sea miles each year during which time the number of passengers carried will be about 150,000. Her first duty is undertaking the work of the well-known "Ulster Monarch," while the latter is undergoing an extensive overhaul and refit which will probably take between three and four months. The new vessel should prove to be a valuable addition to the country's largest coasting fleet.

# A Man and His Tools

By A BARRISTER-AT-LAW

THE true craftsman takes a pride, not only in his work, but also in the condition of his tools. In every sense of the word his tools are his own property: whether he works for an employer or on his own account, the sole responsibility for their maintenance rests with himself, and if he has an accident which is caused by a defect in them his only possibility of recourse is against the supplier, on the grounds that the tools were badly manufactured. At the other extreme comes the machine minder at the factory. He has no tools or equipment of his own, since most of his few tools are peculiar to the machines at which he works. The sole responsibility for the safety of what he uses rests upon the shoulders of the employer, who has a duty at law to provide safe plant and equipment. Between these two, as far as concerns the provision of tools and the responsibility for their upkeep, are the semi-skilled mechanic and the labourer; these two are supplied by the employer with a certain number of personal or semi-personal tools, and they tend to share with the employer or his representatives, the supervisory staff, responsibility for the condition of these tools. Two recent cases in the courts, which have arisen from accidents attributable at least in part to faults in tools, illustrate the limits to the responsibilities of the employer, and the extent to which the workman may expect compensation in an award of damages if he is unfortunate enough to be injured through a fault in his tools.

The more recent of the two cases may conveniently be considered first, since it concerns the responsibility for the maintenance of a tool. A workman in the employ of the Eastern Electricity Board was engaged in knocking a hole through the footings of a brick wall, for the purpose of passing an electric cable through, when the chisel he was using unfortunately rebounded and hit him in the eye. He suffered some severe injury as a result, and sued his employers to recover damages. Since the only basis for an action against an employer in such circumstances is to prove that the employer is at fault in some way, it is always up to the employee, or his representatives, to give particulars of what he suggests ought to have been done, and was not, or what he suggests was done, and was done wrongly. It was alleged on behalf of this workman that the employer was at fault in causing him, or permitting him, to work with a tool which was unsuitable for the job on which he was engaged, in the first place because it was the wrong tool, and in the second place because it was blunt.

In support of the allegation that the wrong tool was provided the workman claimed that the proper tool for the job was a bolster chisel, which was less likely to rebound when being hammered into hard brick. The trial judge, in the High Court, did not decide in favour of the workman on this point, as the evidence suggested that in the normal way a cold chisel was quite safe. In any event, he did not accept the statement of the workman that he had asked for a bolster chisel for the job. In the selection of the tools for the job the workman himself had to bear some responsibility, for he was a man of some fifty-seven years of age, who had had many years' experience at this particular work. On the question of the bluntness of the chisel, however, the claim of the workman was at first successful before the High Court, and the Judge awarded him nearly £800 compensation for his injury. Both the man injured and a fellow-workman stated that the chisel used was not as sharp as it ought to have been for the particular job on hand—the cutting of hard blue brick. On the side of the employers it was stated that on any complaint by a workman a tool was replaced or sent to the workshop for reconditioning, but the Judge thought that the employer should go further than this and institute a system of regular inspection.

The employer appealed, however, and the Court of Appeal took a different view of the obligations of the employer, and reversed the decision of the High Court Judge. In this particular case, they stated, the evidence showed that the tool had been issued new only a few days previously, and a system of weekly inspections would not in any way have ensured a greater measure of safety for the workman. A tool might be fit for a particular job at ten o'clock in the morning, and not fit a matter of two hours later. The workman on the job was the best judge of whether a tool he was using was blunt or sharp, and the best way of ensuring that only proper tools were used was to make it the responsibility of the workman to ask for a fresh one. Then, provided the workman is experienced and the tools are immediately available, the employer is discharging his legal duty to take all reasonable steps for the safety of his men.

It may be mentioned in passing that the workman who was injured had selected the tool from half-a-dozen that morning, and had used it without complaint up till the moment of the accident in the early afternoon. After the accident a member of his gang had continued the job with the same tool. These facts are relevant, of course, in

considering whether or not the tool was in a good condition at the time, but in no way affect the principle of law stated by the Court of Appeal.

It is interesting to note that there is practically no mention of tools in the Factories Act of 1937. Legislation in the factories has grown up gradually and piecemeal over the last century. It has aimed always at the protection of the worker from accidents which are known to occur frequently, and has thus never attempted to cover in a systematic way all the possibilities of accident which are to be found in industrial premises. It has been found by experience (and is still unfortunately proved so every day) that to put a worker at an unguarded guillotine is to invite accident sooner or later. In an effort to prevent accidents, therefore, it is made an offence for an employer to permit an unguarded machine on his premises. At the same time it was thought to give additional protection to the worker, and to simplify his claim against the employer, if he was injured, to require only that he should prove that the regulation was broken, and that his injury resulted from the breach of the regulation, for him to recover damages. He did not have to prove in the courts that the practice of leaving the machine unguarded in those particular circumstances was dangerous.

The basic claim against the employer is older than the factories acts, however. Every employer, whether he runs a factory or whether his premises are outside the Factories Act, has a certain number of basic duties which have never been codified in the statutes but which are, nevertheless, clear and enforceable to-day just as a hundred years ago. One of these primary duties is to provide a safe system of work for the employee, and another is to provide safe plant and equipment. The duty to provide safe plant and equipment has been held in the courts not to include the upkeep of personal tools, but the duty to provide a safe system of work includes the devising of a system of supervision of both the methods of working of the employee and the materials which are put at his disposal. There is no doubt at all that if an employer allows dangerous methods of working or is aware even that such dangerous practices are carried on against express instructions, he is liable for any resulting accident. Similarly, if, through lack of an adequate system of inspection of raw materials, an injury occurs to a workman in his employ, the employer is normally held responsible just as soon as the workman can show that reasonable precautions, or a system of routine inspections, would have averted or prevented the accident.

The employer's duty is, however, limited to a duty of reasonable care : he is not an insurer of the safety of his workmen (except, of course, through the medium of the National Insurance Scheme or a private industrial injury policy), and if he is to be held liable for an injury which has resulted from an accident, it must be through some fault or neglect which is to the ordinary mind culpable. Where (as in the case just considered) a system of inspection would achieve little, and some other method of ensuring a supply of proper materials for a workman is adequate, or better, the employer's duty is discharged. Similarly, where a system of inspection would be regarded as superfluous by ordinary standards, there is no legal obligation upon an employer to check and recheck all possible sources of danger. The duty extends only to what is reasonably foreseeable, as is illustrated by the facts of another lawsuit which arose from an accident in the use of a chisel.

A semi-skilled workman was engaged in chiseling at a factory work bench with a hammer and cold chisel when a chip of metal flew out of the chisel and caused him a severe eye injury. The cause of the chipping was apparently an exceptional hardness in the chisel, which might have been discovered if the tool had been inspected during the course of its use. Apart from this, there could be no suggestion that either the workman himself or the employer could share any of the blame for the accident : the cold chisel was the proper tool for the job on which the workman was engaged, and goggles, which might have prevented the accident, were not customary for the job, nor was there any obligation upon the employer to supply them for that work, still less to attempt to enforce their use. The accident was caused simply by an exceptional condition in the tool. When the workman sought to recover compensation for his injury, therefore, he was left with only two possible causes of action : one was to sue the employer and endeavour to prove a duty upon the employer to inspect his tools at regular intervals. The other was to sue the manufacturer of the tool, on the basis that if the employer was not responsible for a defect in the tool, then it must have been present when it was supplied by the manufacturer, and thus be his responsibility.

In consequence the workman sued both his employer and the tool manufacturer in the alternative, alleging both a defect in the tool as supplied, and a lack of care on the part of the employer in not inspecting the tool on receipt from the manufacturers, and during use. At the trial the Judge decided the question of inspection in favour of the employer, just as in the more recent case discussed above. Some manufacturers, he said, would regard it as a slur on their name to have it suggested that their tools should need to be inspected before use. This employer did not inspect the tool when it was received into his store, or when it was issued to his workman for use, but such an inspection should in the normal way be entirely unnecessary. If he buys his tools from a reputable manufacturer (and this employer had done that), he is not required to take further measures to have the tools inspected. It is possible that a tool supplied in good condition should be subjected to incorrect use, and thus become unfit for a job. In this case, however, the employer was able to prove that the chisel had been issued from his store only two or three weeks before the accident, and had not been subjected to heating and quenching, for instance, which might have altered its temper, in the meantime. The workman in consequence lost his claim against the employer.

It is interesting to note in passing that the workman succeeded in obtaining an award of damages against the manufacturer of the tool, on the grounds that there must have been some defect in the chisel when it left the factory. Once it was proved by the employer that all due care had been taken in use, it followed somewhat naturally that a defect discovered subsequently must have been present in the tool as originally manufactured. The exact cause of the exceptional hardness in the manufactured tool remained a matter of conjecture, because it first appeared a matter of weeks or months after the manufacture, and could not possibly be traced back. This, however, did not prevent the Judge from awarding the workman damages against the manufacturer. It is reasonably apparent, he said, that the tool was defective for some reason within the responsibility of the manufacturer. Once he is able to establish that, the workman who claims his compensation need go no further and show the exact cause of the defect, because that is a practical impossibility.

The importance of this case does not lie in the liability of the tool manufacturer, however (which rests upon other grounds at law), but upon the limits which it establishes to the responsibilities of the employer. Taking the two cases together, his duty for the tools which he supplies to his workmen may be summarised as follows : the employer should obtain his tools from a reputable manufacturer, and there is then no duty upon him to inspect them on arrival at his premises or on issue to his men to use. If tools are of a wasting character they should either be inspected at regular intervals to ensure that they are always adequate for the job or, if the workman using them is experienced and quite able to judge the tools for himself, the initiative in asking for replacement or reconditioning of the tools may be left to him. In this event, though, the employer is under a duty to ensure that replacements are available on request by the workman and that adequate servicing ensures the workman a reasonable supply of good tools. Common sense would suggest that it was unreasonable for the employer to be required to do more than this to ensure the safety of his workmen, at any rate as far as their tools are concerned, and this is the view of the law. The President of the Court of Appeal to which the first of these two cases was taken said that the employer should not be regarded as automatically responsible for any accident which occurs to his workmen : " For accidents of this kind," he said, " employers and workmen pay into the National Insurance Fund, and that is the fund from which the compensation should be recovered." It goes much too far to expect that whenever there is an accident a man can get in addition a further compensation award through an action for damages at law.

## Safety Devices for Agricultural Machinery

A PAPER on slip clutches and mechanical safety devices for agricultural machinery was read by Mr. F. Lee at a meeting of the Institution of British Agricultural Engineers, in London, last Tuesday. Mr. Lee prefaced his paper by saying that the tremendous increase in the tractor population over the past ten to fifteen years had dictated the need for adequate safety devices on farm machines. The methods adopted varied considerably with the nature of the protection required, and the paper made reference to the merits —and otherwise—of friction clutches, overload safety releases and over-running clutches. Mr. Lee suggested, however, that the matter was one about which no definite conclusions could be produced for there was no one particular device which was a panacea for all mechanical problems. Much depended on a fundamental knowledge not only of the different kinds of devices available and their method of functioning, but also on the exact nature of a particular problem, such as the forces and speeds involved, the life required and operational use. Mr. Lee thought it was possible to say in broad terms, however, that where high torques were present the disc clutch might be more suitable than the cone clutch. The jump clutch, he added, was ideal for providing an audible warning to a machine operator, but because of the high shock loads imposed it was not so suitable for speeds in excess of 540 r.p.m.

# Industrial Gas Turbine

*A 250 h.p. gas turbine with single-stage radial-flow compressor and turbine is expected to have peak load and standby applications, and to run continuously on pipeline boost pumps. An overhaul life of 5000 hours is anticipated.*

AN industrial gas turbine resembling in its mechanical simplicity the present under-100-h.p. single-shaft units has been built by the Standard Motor Co., Ltd., to give an output of 250 h.p. By accepting a minimum of thermodynamic refinement, it has been possible to attain a weight of 350 lb, and the installed cost is expected to be less than that of a diesel engine. While the basic engine has a fuel consumption greater than 1·2 lb per horsepower hour, for applications where the utilisation justifies it a turbine of " Nimonic " 90 will allow a greater efficiency. The entire unit is simple in construction, easily dismantled, and suitable for installation and maintenance in relatively primitive conditions.

The arrangement of the engine can be followed in Fig. 3. The principal strength of the engine proper is the cast light alloy compressor housing, seen in Fig. 2. It is noteworthy that the intake annulus is broken only by the support arms, which end well clear of the compressor eye ; there are no whirl vanes, in order to avoid imposing a periodic disturbing force upon the light alloy impeller blades. The blades are straight and radial, but they extend axially in front of the hub and this portion is bent into the direction of the air flow. While the present rotors have been machined from the solid, it is expected that production quantities will be shaped by hot pressing and need no further machining. There are nineteen rotor blades, and in the diffuser seven vanes, individually cast in steel.

To the outer edge of the diffuser is clamped the air casing ; unlike the early version in Fig. 1, this is welded up from 16 S.W.G. mild steel, aluminised inside, aluminised and painted outside. Within it are two Lucas combustion chambers ; they are retained by, and the sprayers carried in, two circular caps also held by " King Clamps." Radial swirlers admit the primary air, small shields in front of the sprayers directing a small air flow across them to prevent sooting at low loads ; the secondary air enters through holes, the relatively high pressure loss of 3 lb per square inch being allowed. Surface discharge igniters are fitted, but in production engines it is anticipated that sparking plugs will be used, with a cross-fire tube to guard against only one chamber lighting. The tertiary air is added where the chambers merge into the volute of " Nimonic " 75 ; guides extending from the flame tubes proper prevent the gases passing too early into the front of the volute.

The turbine nozzle assembly is located on the ring seen on the rear face of the compressor housing, and the seven bolts holding the turbine together against gas pressure are ball-ended to allow them to rock as the turbine expands. The shroud plates are " Nimonic " 75 and the diaphragm carries at its inner radius a copper ring which meters the air flow from the compressor periphery on to the back of the turbine rotor. For engines running at a temperature of 777 deg. Cent. (1050 deg. K), nozzles of Jessops R.22, like the diffuser vanes, and a rotor of " Rex " 535 are used. The shroud ring against which the open face of the rotor runs is a " Centrispun " casting bolted to the outer " Nimonic " plate. It is found that, while for a strict assessment of rotor life the overall diameter should be measured, the cooling of the rotor disc results in the trailing edges of the blades creeping at the same rate, and the clearance at the exhaust end is a reliable indication of serviceability. The exhaust duct is bolted on, and contains the exit bullet, supported by sets of four struts well downstream from the rotor. The exhaust trunking is attached by another quick-release clamp.

The mainshaft runs on two high-speed bearings that are catalogue products. The reduction trains, contained within a light alloy casting on to which the compressor intake, and hence the rest of the engine, is attached, are shown in Fig. 4. It will be noted that the primary wheels are bolted up ; in order to ensure that the layshafts share the power equally, it is necessary to build up these trains with equal backlash. The turbine speed is 24,000 r.p.m., and reductions as great as 16 : 1 in two stages are available, but for alternators 8 : 1 would generally be used ; the variation is made on the secondary train, and the pump drive from the layshaft in all cases runs at 3000 r.p.m.

A Hobourn Eaton gear pump circulates S.A.E.10 engine oil through a full flow filter to jets spraying on the gears and bearings ; a

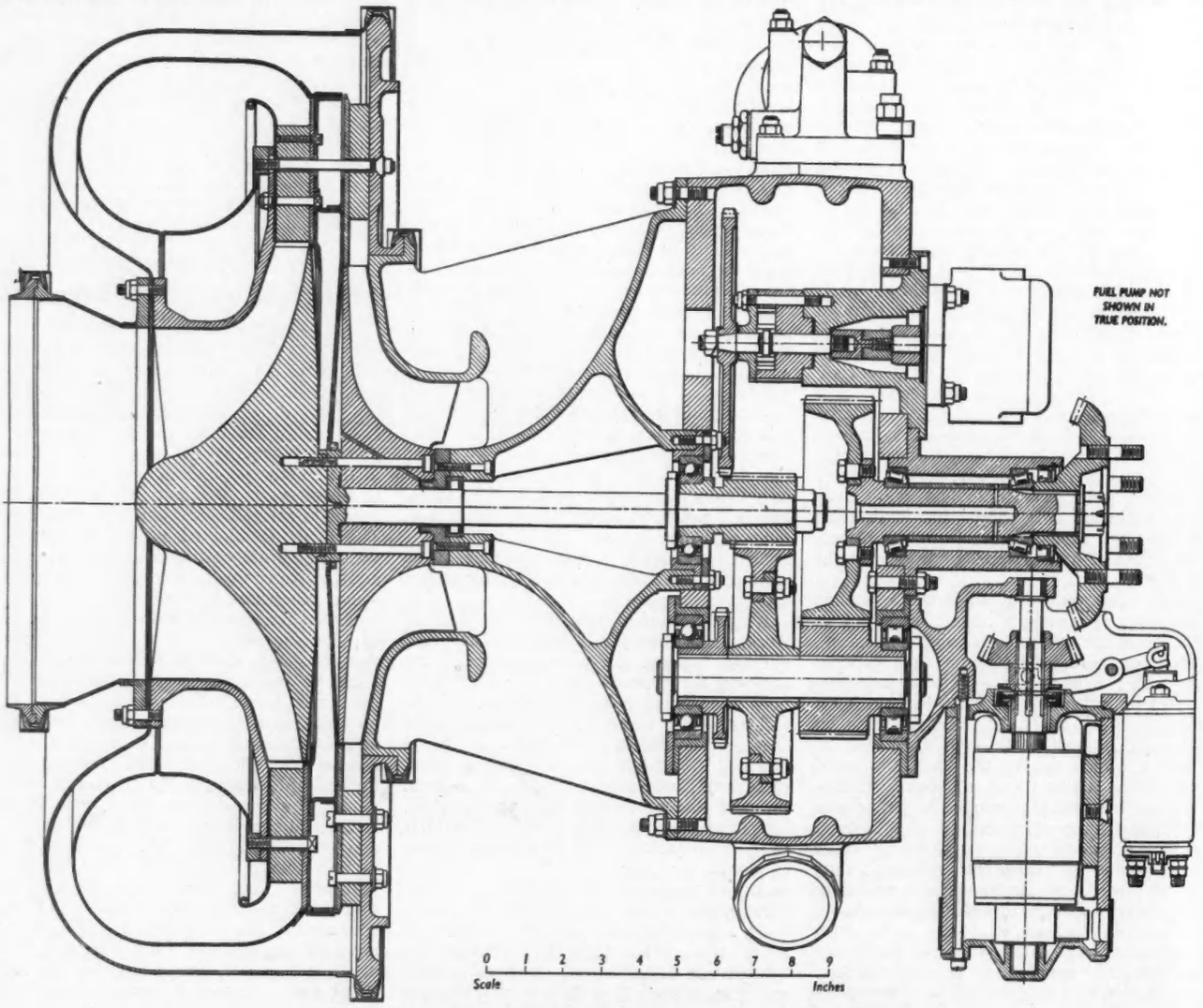



**Fig. 1—Transverse section showing general arrangement of power plant**

labyrinth seals off the compressor and the oil runs back into a 12 pint sump in the gear case. The fuel system is intended for constant speed applications, and is correspondingly simple; control of the engine is by turning the fuel on or off.

Three fuel systems are available. That seen in the illustrations is supplied by Dowty Fuel Systems, Ltd., and employs compressed air in its control system, the tapping from the air casing being seen in Fig. 3. The air passes to a spill valve, the pressure at which is regulated by a governor on the pump; thus the spill valve controls the supply to the burners. A second pipe can be seen running to the sprayer; this

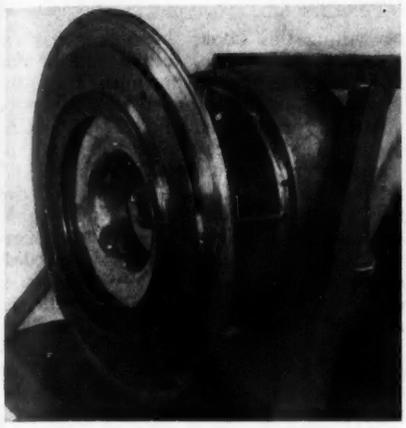


**Fig. 2—The compressor housing and diffuser assembled upon the intake casting and gearbox**

carries an augmenting fuel supply which is brought into action automatically under acceleration when the control system calls for more than the full load fuel delivery; this corresponds to 700 lb per square inch pressure at the burner.

The Lucas system employs a swashplate pump fitted with a centrifugal governor regulating the delivery pressure. Between the pump and the sprayers a pressure-responsive bypass valve is fitted which renders the turbine more sensitive to pump pressure and hence gives closer governing. A fuel system with a self-contained Plessey pump can also be used.

The turbine is started by an automotive 12V series-wound motor, the bevel drive being held in mesh by a solenoid through a rocking fork. The igniters fire whenever the motor is energised, but the fuel cock must be opened by the operator as the engine gains speed. For the 350 h.p. version which is contemplated, using the same components but deeper diffuser and nozzle passages, a second motor can be fitted opposite the first.

When the engine was demonstrated to us, ignition took place after five seconds cranking—nominally 2800 r.p.m.—and within twenty seconds the engine was idling, the turbine inlet temperature having risen to 1000 deg. Cent. and settled at 600 deg. Cent., but the exhaust not having exceeded 600 deg. Cent. The self-sustaining speed is expected to be 5000 r.p.m.; the radial-flow turbine is regarded as relatively immune from damage by excess fuel at starting. After idling for some time, the plant was allowed to cool and the engine proper stripped; the working parts were removed in little more than twenty minutes.

Development running has been done on kerosene or diesel oil, but it is expected that the ability to burn crude oil for such duties as oil pipeline boosting will be provided. The fuel consumption is expected to be 1·3 lb to 1·5 lb per horsepower hour at speeds of 24,000 to 22,000 r.p.m. at 777 deg. Cent.; at full power the pressure ratio is 3·0 and the air consumption 5·2 lb per second. The makers have great faith in a heat exchanger that is being developed for the engine; of plate pattern without secondary surface, it will provide a thermal ratio of 0·75 with the high coefficient of performance necessary for an inefficient cycle, and is expected to halve the specific fuel consumption. The overhaul life of the engine is 5000 hours; at that time the entire high-speed line is replaced by new parts costing perhaps 20 per cent of the price of the plant. An alternative set is to be marketed in which no provision is made for power take-off, the output being entirely compressed air.

## Fire Resistant Cables for Aircraft

A NEW kind of aircraft cable known as "Tersil" has been developed by W. T. Henleys Telegraph Works Company, Ltd., 51-53, Hatton Garden, London, E.C.1, for use on the "Proteus 755" turbo-prop engine and on power plants in the Bristol "Britannia 300."

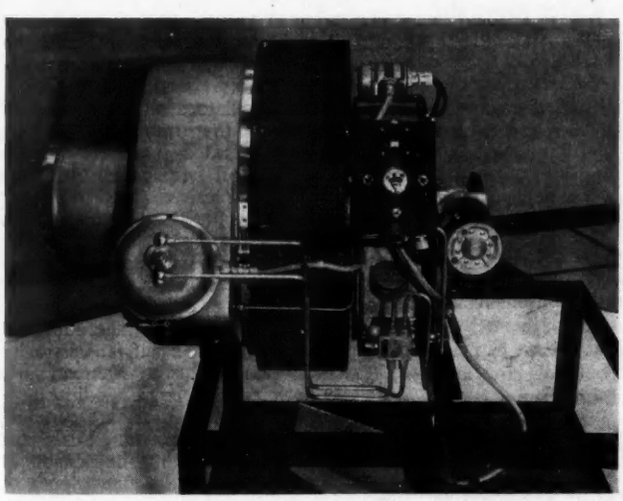
The introduction of "Tersil" cables has closed the temperature gap between the "Pren" and similar cables (which are designed for use up to a maximum temperature of 90 deg. Cent.) and the more expensive p.t.f.e.-insulated "Unief" and "Glasef" cables which are designed to withstand much higher temperatures. To some extent "Glasil" cables have filled the existing gap in service temperatures, but the use of these cables has been limited because of their large size, poor resistance to fluids, and a tendency to transmit fire when soaked with fuel or oil.

"Tersil" cables have nickel-plated copper conductors and insulation consisting of silicone rubber, with a composite covering of glass, and polythene terephthalate, which is the chemical name for materials better known as Terylene and Melinex. This construction enables the cable to function continuously in ambient temperatures ranging from −50 deg. Cent. or lower to +150 deg. Cent, and to continue in service during and after a fire. The latter fact has been demonstrated by twisting two of the cables together and subjecting them to a temperature of 1000 deg. Cent. in a flame from a special Calor gas burner, while a voltage of 250V was maintained between them for up to twenty minutes without any sign of electrical breakdown, even when the twisted cables were shaken vigorously. This property is of great value, and allows the cable to be used on essential service circuits in aircraft where it is imperative that the circuit functions under fire conditions. The ability of this cable to operate during a fire is a result of the inclusion of silicone rubber in its construction, for this material, when heated in a flame, burns slowly, leaving a residue of silica ash, a good insulator which, when suitably supported, as in the "Tersil" cable construction, remains in position even when vibrated mechanically.

The ratio of insulation resistance of "Tersil" to that of "Pren" is of the order of 250 to 1, and the straight 50c/s breakdown voltage of a "Tersil" cable having a 40/·0076in conductor is of the order of 12kV. The electrical properties are maintained both at high and low temperatures, and also after prolonged immersion in water. The protection given by the composite covering, which is specially heat-treated, makes the cable proof against the effects of fluids, including kerosene and ester base lubricating oils, even at high temperatures.

A range of single-core cables known as Henley "Uni-tersil" is now being manufactured. The conductor sizes and overall dimensions are identical with those of the "Uni-pren" cables. Screened cables, having a tinned copper metal braid applied overall, are being made under the name of "Uni-tersilmet." "Tersil" cables are lighter, particularly in the smaller sizes, than the corresponding size "Pren" cables.

REPAIR OF A LARGE CASTING BY "METALOCK."—Particulars have been received from Metalock (Britain), Ltd., 638, Grand Buildings, Trafalgar Square, London, W.C.2, of a large repair job carried out at the Bromborough power station. The repair was made to the 12½-ton cast iron casing of a rotary strainer, the two top quarters of which were badly fractured. The top inlet quarter was broken through the flange of the access door, and the top outlet quarter was broken into three pieces, the total length of the fracture being some 29ft. In the repair operation, nearly 1400 "Metalock" keys were used to reassemble the broken parts, and the lines of the fractures were then sealed by "Metalacing."



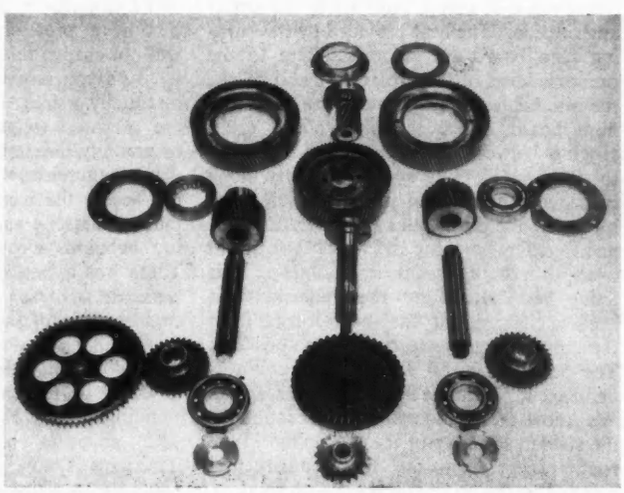


**Fig. 3 (Left)—The single-shaft gas turbine with a Dowty fuel system installed. On the right of the air cleaner can be seen, top to bottom, the igniter coils, gas and oil thermometers, pressure warning lights, starter switch, oil filler cap and fuel cock. Below the starter motor is the solenoid holding the bevel gear in mesh: the bevel wheel is the output flange Fig. 4 (Right)—The primary pinion drives two wheels in order to minimise the load on the high speed ball bearing. Various ratios are available for the secondary reduction: the 3000 r.p.m. oil and fuel pump drive is taken from one of the layshafts. In the foreground are the bevels of the starter train**

# LETTERS AND LITERATURE

## Letters to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents.)*

### THE "JAGUAR" FIRE

SIR,—Many of your readers will have a professional interest in the contribution of the roof construction at the Jaguar factory to the spread of fire, and must have been confused or misled by the conflicting statements which have been made on the subject and the lack of any factual description of the nature of the roof construction itself. I think, therefore, they may be interested in the information set out below, which has been compiled from an inspection carried out at the Jaguar factory within forty-eight hours of the fire.

The fire took place in a factory which was constructed in 1939 when the roof consisted of §in fibre insulating board laid over the supporting steelwork and fixed by a specialist contractor, over which my firm placed the cladding of corrugated protected metal sheets. During the war twelve bays at the north end of this factory were damaged by enemy action, in which the whole of the fibre board lining in this area was lost and corrugated protected metal sheeting only was restored as necessary, fixed hard down upon the purlins. When the building was subsequently relined after the war, ½in natural fibre board was placed below the supporting steelwork, i.e. 4in below the protected metal roof, so creating a cavity roof construction. This was presumably carried out by a specialist insulation contractor.

The fire began at the north end of this area in a store containing large quantities of tyres and finished components, many of them in wrappings or in cartons, and intense heat was generated fairly rapidly. As this reached the underside of the roof lining, the fibre board took light and the flames spread along the roof lining, both inside the cavity and outside. The heat provided by the burning fibre board 4in below set light to the outer cladding of the protected metal sheets, the bitumen coatings of which fell on to the fibre board before the fibre board itself, sagging between its unsupported tees, fell to the ground. Fire spread similarly along subsequent bays at an increasing rate until it reached the thirteenth bay, which had been unaffected by bombing and where the original over-purlin lining was therefore intact. This lining was burned on the underside and became charred, but was not dislodged from the supporting tees and remained in position. The protected metal sheeting above it was unaffected. Here the spread of fire stopped. We know of no factors which account for the sudden stopping of the fire spread in the roof, except that the roof construction reverted to the original form at this point.

It is our opinion that had the building been unaffected by bombing and the original construction remained intact throughout, even with the natural fibre board which was the only material of the kind available at the time the factory was built, the spread of fire in the roof would have been confined to three half bays. Had asbestos-faced insulation board or an incombustible building board been available, the spread of fire would have been even less.

What, then, are the lessons to be learned from the Jaguar experience ? In our opinion, there are three :

(1) That if fibre board is used to provide underdrawn insulation for a roof, it is important that it should be of the asbestos-faced type which has a Class I spread of flame rating. An alternative would be to use an incombustible building board. Neither of these materials was available at the time the Jaguar factory was built.

(2) An underdrawn lining should be placed close to the external cladding so as to avoid the formation of a cavity, along which flame can rapidly be funnelled.

(3) That the construction should be such that the underdrawn lining is firmly anchored to the cladding material so as to avoid the possibility of its falling in a blazing mass and so spreading fire.

These are principles which we have long advocated and practised.

ROBERTSON THAIN, LTD.,
(C. Thain),
Managing Director.

London, S.W.1,
March 7, 1957.

### THE STATUS OF ENGINEERS

SIR,—Referring to the comments in your leader entitled "Russian Education for Engineers" in your March 1 issue, may I suggest that the basic trouble is not that schoolmasters have no understanding of the cultural and intellectual content of a career in engineering ; it is simply that the status of an engineer is that of a hired hand, not that of a professional man. Our society will not change this and, indeed, why should it ? As you remark in your leader ours is essentially a free economy and if engineers are prepared to give their services to the community on terms which a professional man would reject, why should the community not accept the bargain offered ? (The fact that in the long run it is a poor bargain is too nebulous a deterrent to be effective.) There was a time, I believe, Sir, when you were an advocate of the establishment by engineers of professional status for themselves. Presumably you were, in those days of mass unemployment, thinking only of how nice it would be for engineers to have a better standing. May I suggest that you renew your advocacy because something more important is now at stake : the supply of adequate numbers of creative engineers to maintain the standard of living in this country.

BRISTOLIAN

Luton,
March 6, 1957.

## Literature

**Transistors in Radio and Television.** By MILTON S. KIVER. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 37s. 6d.

IN writing this book, the author has set himself a task which, to the best of our knowledge, has not been previously attempted in spite of the increasing number of books on transistor subjects. He has set out to produce a fairly comprehensive book of particular use to the practical man, such as the radio technician ; a book which will give him a good grounding in the electrical properties of transistors and their circuit application. In this aim he has largely succeeded, the greater part of the book dealing in a competent and practical manner with the usage of transistors in radio and television. It is well supplied with circuit diagrams giving component values and other detailed information. Inclusion of a chapter describing a number of basic transistor experiments is an excellent scheme for this kind of book, and the provision of a set of questions after each chapter helps to make it suitable for use as a technical school textbook. Two chapters at the beginning give a non-mathematical introduction to semi-conductor theory and the physics of transistor operation, and there are several sections describing the construction and properties of various transistor types. It is appropriate that the chief emphasis should be on linear applications, a few references to pulse circuits being mostly in the chapter describing possible applications of transistors to television receivers. The latter section explains that application of transistors to horizontal time-base output circuits is impracticable at present, due to limited power and voltage handling capabilities of available transistors, but it does seem a pity not to have mentioned the inherent advantages of transistors for such use, due to their excellent switching properties and the very high efficiencies which can consequently be achieved.

For the most part the book is thoroughly sound, though one or two points must be questioned—for example, the implication on page 185 that noise is unimportant in a receiver local oscillator transistor, coupled with a statement that transistors in such stages may be operated successfully above their nominal cut-off frequencies. In point of fact, in many receivers local oscillator modulation noise is the greatest noise limitation, especially when the oscillator transistor is operated close to the current gain cut-off frequency or above it. On page 253 it is stated that transistors are very sensitive to changes in supply voltages. The author is evidently chiefly concerned with the possibility of transistor damage due to overload and, since the power and voltage handling capabilities of existing transistors are certainly limited, some warning concerning this aspect is justified. A misleading impression is created, however, since, in many types of circuit, when properly used, transistors can operate reliably and safely in spite of supply variations of much greater relative magnitude than the changes which could be tolerated by hard valves. Another case of under-

statement concerning the transistor's capabilities occurs in the introductory paragraph where insufficient emphasis is placed on the very large saving in power which can result from their use and on the fact that, unlike the hard valve case, high working efficiency can be maintained down to extremely low power levels. It might, too, have been preferable to reduce reference to new devices, especially the more revolutionary ones, which are still in the experimental stage, may never come into use, and serve only to confuse the newcomer to the field. More space might then have been devoted to some of the circuit principles, for example, to explain more fully the necessity for neutralisation and the means by which it is achieved. Fuller description of transistor test methods and test equipment would have been useful.

But against these few items calling for critical comment must be set a considerable volume of reliable information, which should prove very valuable to a rapidly increasing body of technicians interested in the practical application of transistors.

**Principles of Physical Metallurgy.** By MORTON C. SMITH. Constable and Co., 10, Orange Street, London, W.C.2. Price 50s.

**Alloy Series in Physical Metallurgy.** By MORTON C. SMITH. Constable and Co., 10, Orange Street, London, W.C.2. Price 50s.

THE first of these volumes begins with an account of the progress that has been made in the field of metal physics, including the structure of the atom and of metallic crystals, energy levels within the atom, binding forces in crystals, and polymorphism. This is followed by discussions of crystal imperfections, electrical and magnetic properties and the major factors that influence them, and deformation in metals. On this basis the mechanical properties of metals are considered under three headings, the effects of permanent deformation, the effects of elevated temperature, and fracture, with the object of indicating the mechanism of their behaviour and the means whereby this can be modified and improved. These three chapters are of an essentially practical nature. The author states that he is prepared for criticism from " the down-to-earth " engineer because of complexity and over-elaboration, but anyone must expect some degree of complexity if he is to gain an understanding of the principles of metal physics as set out in the early chapters of this book.

When, however, as in the book on *Alloy Series*, some background of physical metallurgy is assumed, it does appear that those parts of the first six chapters which deal with the construction and significance of constitutional diagrams, though by no means complex, are unnecessarily prolix. However, apart from Chapter 9 on ternary and higher alloys, these are the only chapters containing references to the non-ferrous alloys. A detailed description is given of the constitution of a wide range of alloys, including those of industrial importance, like the age-hardening alloys of aluminium and the copper alloys, as well as many alloys which are of importance only because of some peculiarity in their constitutional diagram. Chapter 7 deals with steels and contains valuable accounts of the constitution of steels, the principles underlying heat-treatment, isothermal transformations, carburising, nitriding and carbonitriding. Chapter 8 deals similarly with cast iron and contains a lengthy discussion of graphitisation. All temperatures in both volumes are in degrees Fahrenheit. Numerical values of stresses are rarely, if ever, mentioned. There is an excellent index in each book.

A student working through these two volumes could obtain a fundamental understanding of the thermal and mechanical behaviour of metals and alloys, and engineers and metallurgists would be likely to find many of the summarised conclusions and views expressed helpful in interpreting unexpected behaviour or seeking for improved materials.

**High-Speed Small Craft.** Second edition. By PETER DU CANE. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 40s.

THE first edition of this book was published in 1951 and the second edition has been largely revised and expanded, there being additional technical material and new chapters dealing with special subjects. The book examines the various designs of high-speed craft, their seaworthiness and manœuvrability and the performance of planing craft in theory and practice. Consideration of rudder design is followed by some remarks about materials and structural requirements, and an examination of the application of plastics, light alloys and plywood in the construction of small craft. Particulars of several main propelling machinery units and reverse gears are noted, together with some of the installation problems encountered. There is a chapter devoted to model experiments and the development of the planing form, and another which discusses propeller design and gives details of a particular method. General reference is made to speed trials and the concluding chapters touch upon dynamic stability, as applied to longitudinal and directional stability, and the use of scale models for the prediction of rough water behaviour.

**Rules and Regulations for the Construction and Classification of Steel Ships, 1956.** Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. Price 42s.

THE volume contains fourteen chapters which are listed alphabetically, and the first three deal with general rules and regulations concerning classification and periodical survey. All the remaining chapters are devoted to the exposition of the constructional rules, and Chapter D refers to steel ships, including a special section having special reference to petroleum tankers and tables of scantlings and equipment. Some chapters cover certain ships' services, such as pumping and piping, fire extinguishing and refrigeration, while others set forth the rules for boilers, steam and internal combustion engines, gearing, electrical propelling machinery and equipment. Membership of the various Lloyd's committees is given and also details of the headquarters and surveying staff, and there is an excellent index.

## Books Received

*The History of Electric Wiring*. By John Mellanby. Macdonald and Co., Ltd., 16, Maddox Street, London, W.1. Price 32s. 6d.

*The Electrical Production of Music*. By Alan Douglas. Macdonald and Co., Ltd., 16, Maddox Street, London, W.1. Price 28s.

*Mathématiques Générales*. Sixth edition, Vol. 1. By Maurice Denis-Papin. Dunod, 92, Rue Bonaparte, Paris, 6. Price 480 francs.

*The General Theory of Electrical Machines*. By Bernard Adkins. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

*Directory of Shipowners, Shipbuilders and Marine Engineers*, 1957. Compiled by *Shipbuilding and Shipping Record*. Tothill Press, Ltd., 33, Tothill Street, Westminster, London, S.W.1. Price 40s.

## Books of Reference

*American Civil Engineering Practice*. Vols. I and II. Edited by R. W. Abbett. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 120s. for each volume.—Over fifty prominent American civil engineers have contributed to the various sections of this book, which is intended as a comprehensive work of reference over the whole gamut of civil engineering practice in the United States. It is pointed out that the book replaces the *American Civil Engineer's Handbook*, originally published in 1910 and edited by Professor Merriman ; the latter work had been revised on several occasions, but it was considered that further revision would not be sufficient to serve present-day needs and so the new volume was prepared.

The aim of the present work is to present fundamentals and techniques (but not derivations of fundamentals) in a form suitable for guide reference by practising engineers. Engineering fundamentals and properties of materials are dealt with in similar companion volumes.

Progress in all branches of engineering is so rapid that it could not be expected that all the most modern refinements would be presented in a book of such wide scope. For instance, the effect on airport construction of the large jet-propelled airliners which are to come into service in a few years' time is not dealt with. Some such developments are still too loosely defined, and presumably will not find their way into works of reference until they become standard practice ; probably similar examples could be given for most of the sections of the book. Generally speaking, however, the basic data for each of the sections are presented in a concise and practical manner. The principal sections are, in Volume I : metropolitan and community planning ; surveying ; traffic engineering ; highway engineering ; airport engineering ; railroad engineering ; soil mechanics and site investigation ; foundations ; earthworks and dredging ; tunnels ; and mathematical tables. In Volume II, the sections are : hydraulics and pumping ; hydrology ; dams ; river engineering ; hydro-electric power ; irrigation and land drainage ; public water supply ; sewerage and sewage disposal ; refuse collection and disposal, and harbour engineering.

*Handbuch der Werften*, 1956. Editor of the technical section, Professor Dr.-Ing. K. Wendel. Schiffahrts-Verlag " Hansa " C. Schroedter and Co., Hamburg 11, Stubbenhuk 10. Price DM. 32.—In the present fourth edition of the " Handbook of Shipyards," the technical section has been extended by many new subject headings. Of particular interest is the monograph by Dipl.-Ing. Krappinger on inland shipping, a field which has been treated somewhat scantily in the technical press in recent years. Ocean-going fishing vessels and factory ships are dealt with by C. Boie in the next section, while Prof. Wendel briefly describes the carrying out and evaluation of model tests. Mention may be made also of Dr.-Ing. Schubert's contribution on the subject of German fire safety regulations, and A. Steuer's chapter on accountancy in shipyards. Dipl.-Ings. Ehmsen, Heil, Wangerin, Fincke and Rothardt deal with the manifold mechanical and electrical power applications. In the second main section, information will be found on German shipyards of all categories, while a third section gives a survey of German organisations and institutions in the field of shipbuilding.

*Smoley's Four Combined Tables*. By C. K. Smoley. The Technical Press, Ltd., 1, Justice Walk, Chelsea, London, S.W.3. Price 100s.—This is the eleventh edition of a book printed in the United States, and now available in this country. The tables which it contains are as follows :—(i) Tables of logarithms and squares for $\frac{1}{64}$in intervals up to 5ft, for $\frac{1}{32}$in intervals from 5ft to 50ft, $\frac{1}{16}$in intervals from 50ft to 100ft, and $\frac{1}{8}$in intervals from 100ft to 300ft. These are followed by charts giving data on right-angled triangles, by tables of angles and trigonometrical functions corresponding to bevels of height " *s* " on a 12in length, and tables for rivet spacing ; (ii) tables of slopes and rises, and further " bevel " tables, for roof design laid out after a similar style to the first section ; (iii) logarithmic and trigonometrical tables, and (iv) segmental functions.

*Streamlined Specification Standards* : Vol. II, *Electrical and Mechanical*. By L. Axelbank and B. J. Small. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 80s.—This is an American volume, intended as a guide for the specification writer concerned with the electrical and mechanical equipment for buildings—that is, all buildings except houses. It is claimed that the book is a complete guide to orderly and intelligently organised specification writing. Information is presented " stripped of all excess verbiage." All work is referred to American practice and standards.

# Synthetic Fluids for Transformer Cooling

## No. I—THE PROPERTIES OF "PYROCLOR"

By P. D. WILMOT, B.Sc., A.Inst.P.* and N. G. H. THOMAS, B.Sc.†

*The demand for fire-resistant power distribution transformers has been met in the United Kingdom mainly by air cooling, but in the U.S.A., Canada, France, and elsewhere there has also been a considerable parallel development of synthetic coolants, or "askarels." In America the classification "askarel" has been given to any completely fire-resistant transformer fluid,[1] and of this class, the most important fluid has been a blend of 60 per cent hexachlorodiphenyl and 40 per cent trichlorobenzene, known by various trade names, such as "Pyranol" and "Inerteen." Such a blend is produced in the United Kingdom by Monsanto Chemicals, Ltd., and is marketed under the name "Pyroclor." The properties of the fluid are discussed in this article. The design and application of transformers using this fluid will be dealt with in next week's article.*

### Fire-Resistance

THERE are two aspects to the fire-resistance of a transformer fluid. In the first place the inflammability of the fluid itself is to be considered. "Pyroclor" will be found to have a flash-point when examined by the usual laboratory tests, but this flash burns with a "cold" flame and no fire is carried back to the liquid phase[2]; therefore there is no corresponding fire-point. The autogenous ignition temperature of "Pyroclor" has been measured by dropping small quantities of the fluid on to the floor of a ceramic-lined muffle furnace; the liquid did not take fire until the surface was dull red at 700 deg. Cent. Once the liquid leaves such a hot surface it ceases to burn and it is therefore impossible to convey fire by a moving stream of the fluid. The laboratory of the National Board of Underwriters (U.S.A.) have carried out stringent tests of the fire-resistance of an "askarel" of this type and have concluded that it is essentially non-inflammable.[2]

The other aspect of inflammability is the combustibility of the products of decomposition by an electric arc. When an arc occurs in oil, the principal decomposition product is hydrogen—which introduces a further fire and explosion hazard. Many tests have been carried out to determine the constituents of the gases evolved from "Pyroclor" when decomposed by an electric arc, and typical results are shown in Table I.[3]

Table I—*Constitution of Arc-Formed Gases*

| | Per cent | | Per cent |
|---|---|---|---|
| Hydrogen ... ... | 0 | Carbon dioxide ... | 0 |
| | | Oxygen ... ... ... | 0·25 |
| Hydrocarbons: | | | |
| Saturated ... ... | 0 | Nitrogen ... ... ... | 2·0 |
| Unsaturated ... | 0·50 | Hydrogen chloride ... | 97·0 |
| Carbon monoxide ... | 0·25 | — | — |

It is seen that this gas consists of hydrogen chloride, which is non-inflammable and which will not form explosive mixtures with air in any proportions. It has sometimes been suggested that the highly toxic gases, chlorine and phosgene, are evolved, and therefore all investigators have made a particular point of searching for these two gases; no trace of either has ever been found.

Experience has shown that even if, through a catastrophic internal failure, a "Pyroclor" transformer should explode, there will be no fire. The only effect would be to discharge hydrogen chloride gas and "Pyroclor" vapour into the atmosphere. The former is an unpleasant and irritating gas to breathe, but it is strongly soluble in water and is easily detected in the atmosphere and exposure to low concentrations would produce no lasting ill-effect. The fumes of "askarel" are also unpleasant and irritating, but they could produce a lasting ill-effect only on very prolonged exposure over a period of months. The fumes are easily detected and there is no likelihood of anyone being exposed to harmful concentrations without being aware of it. "Askarel" transformers by virtue of their superior ageing characteristics, are even less liable to failure than their oil and air-cooled counterparts and for this reason alone considerations of toxic hazard may be ruled out. The conditions that could produce breakdown in an "askarel" unit could produce a serious fire in the alternative cases and this is without doubt the greater hazard. However, even if the worst were to happen, within minutes of the failure most of the vapour would have condensed and cleaning up the space in which the transformer was located would be a simple operation.

### Dielectric Properties

A transformer fluid is employed partly to act as insulation in and between the windings of the transformer. Therefore, the dielectric breakdown strength of a coolant is of importance. The breakdown strength of "Pyroclor" was, therefore, measured as a function of electrode spacing at room temperature, using B.S. 148 electrodes. Alternating current at 50 c/s was applied, rising in steps of approximately 3kV, but held constant for one minute between steps, until breakdown occurred. The measurements were made on successive samples of transformer fluid drawn from different production lots and extracted from drums at the plant. The results are plotted in Fig. 1.

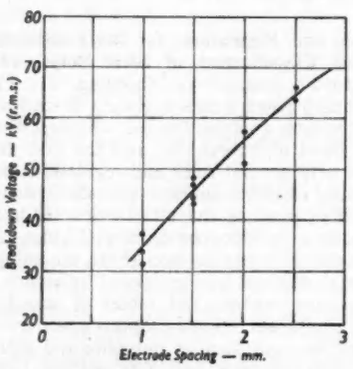



Fig. 1—Breakdown voltage as a function of electrode spacing (B.S. 148 method)

Again using B.S. 148 electrodes, breakdown strength as a function of temperature for a constant electrode spacing of 2mm has also been measured, all samples being extracted from a single drum. The results are shown in Fig. 2.

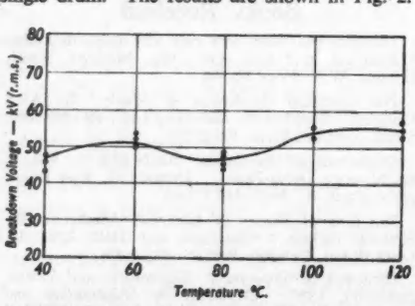



Fig. 2—Breakdown voltage as a function of temperature (½in sphere electrodes—2mm gap)

There is a slight drop in breakdown voltage in the region of 80 deg. Cent., but this may be due to dissolved gases coming out of solution at this temperature. These data demonstrate that "Pyroclor" is equal to the best quality mineral oil and has the dielectric qualities required for the voltage stresses encountered in transformers over the entire temperature range of operation.

In operation, a transformer is certain to encounter impulse over-voltages due to switching or to lightning, and it is therefore important to know how the fluid reacts to such stresses. Dakin and Works have examined the breakdown strengths of purified mineral oil and of "Pyranol" using A.S.T.M. method of test (discs, 1in diameter) and the results are seen in Fig. 3.[5]

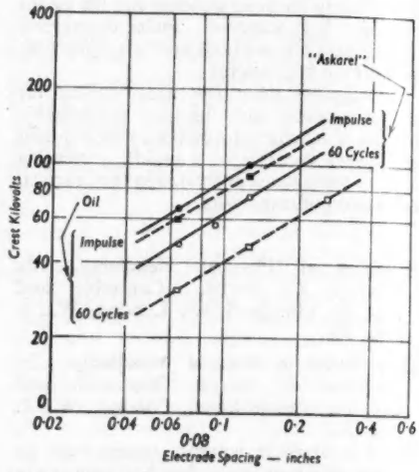



Fig. 3—Dielectric strength of "askarel" and mineral oil (1in diameter "square edged" disc electrodes)

The type of impulse was that defined by A.I.E.E. Standards (1½×40 wave). It is seen that the impulse ratio of "Pyranol" is less than that of oil, but nevertheless, the impulse breakdown strength is still higher than that of oil. On the other hand, it was found that although pressboard impregnated with the fluids gave a higher 60 c/s breakdown strength with "askarel," the impulse breakdown strength of such pressboard was much higher for oil than for the synthetic fluid (Fig. 4), especially if the field converged towards the positive electrode. This was shown to be a characteristic of chlorinated fluids. Somerman, Bute and Larson[6] showed by a photographic paper technique and a succession of chopped waves that pre-breakdown ion tracks developed much faster with the chlorinated fluids than with the mineral oil, and that such tracks were more concentrated with the former fluid.

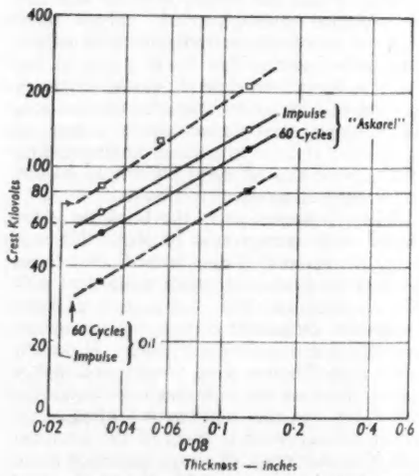



Fig. 4—Dielectric strength of impregnated pressboard (1in diameter "square edged" disc electrodes)

The principal dielectric property of importance is breakdown strength, but other properties also play a part in the behaviour of the "Pyroclor."

* Formerly with Monsanto Chemicals, Ltd. Now with Mond Nickel Company, Ltd.
† Monsanto Chemicals, Ltd.

First, permittivity from room temperature to 100 deg. Cent. lies within the range 4·5 to 4. There is, therefore, a greater uniformity of stress in impregnated pressboard, and this fact is the principal cause of the increase of breakdown strength reported above.

The acidity (i.e. hydrogen ion concentration) of a mineral oil sample is regarded as a very useful criterion of its condition, and numerous investigations have been made to find a correlation between volume resistivity or power factor and breakdown strength. As oil oxidises, acids, water and sludge are formed. These are known to increase conductivity and to diminish breakdown strength. With "askarel," however, a low resistivity or high power factor by no means predicates a low breakdown strength. In Table II

TABLE II—*Power Factor Contamination Produced by Transformer Materials Aged in "Askarel" at 100 deg. Cent. for Ninety-six hours*

| Material | "Askarel" power factor, per cent (60 c/s) | Dielectric strength, kV |
|---|---|---|
| None | 1·0 | 35 |
| Black varnished cloth | 85·0 | 42 |
| Copper | 1·5 | 40 |
| Pressboard | 2·0 | 37 |
| Manila paper | 1·5 | 39 |
| Bakelite | 1·6 | 41 |
| Shellac | 6·0 | 36 |
| Iron | 5·0 | 39 |
| Synthetic rubber | 70·0 | 39 |

are shown data presented by Clark, which demonstrate this point.[7] "Askarel" that had been so heavily subjected to arcing that it appeared as a black fluid on account of the carbon present in suspension has been examined. The volume resistivity of this fluid was $5\times10^{5}$ ohms-cm, compared with an initial value of $10^{13}$ ohms-cm. Despite this, the breakdown strength by B.S. 148 (4mm gap) was 40kV. Clark maintains that there is no necessity to examine periodically the power factor of "askarel" transformers when in service.[7]

Resistivity or power factor measurements can, nevertheless, be very useful in assessing the suitability for use with "Pyroclor" of the various materials of construction.

## Physical Properties of "Pyroclor"

The following physical properties of a cooling fluid are of importance in transformer design: viscosity, density, coefficient of expansion, specific heat, thermal conductivity, pour point, vapour pressure and Bunsen coefficient.

The values applicable to "Pyroclor" are outlined below.

*Viscosity* (Fig. 5).—In developing the original

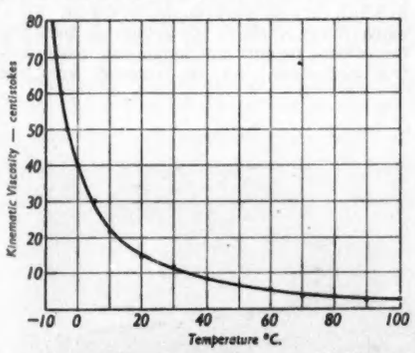



**Fig. 5—Viscosity of "Pyroclor" as a function of temperature**

"askarel" in America, the blend 40–60 per cent trichlorobenzene-hexachlorodiphenyl was selected because it gave a viscosity/temperature curve very similar to that of transformer oil.

*Density* (Fig. 6).—The density/temperature relation is shown in Fig. 6; "Pyroclor" is roughly twice as dense as mineral oil.

*Coefficient of Expansion.*—The coefficient of expansion in the range 20 deg. to 100 deg. Cent. is approximately 0·0007 per deg. Cent., which is of the same order as that of mineral oil.

*Specific Heat.*—The specific heat has been measured over the range from room temperature to 80 deg. Cent. A mean value of 0·26 cal per

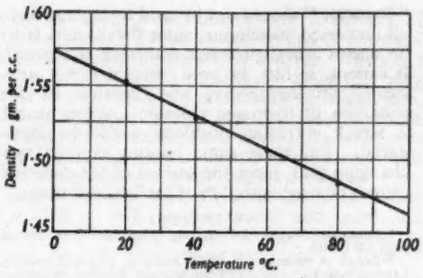



**Fig. 6—Density of "Pyroclor" as a function of temperature**

gramme per deg. Cent. was obtained, which is about one-half that of mineral oil.

*Thermal Conductivity.*—The thermal conductivity at 50 deg. Cent. is approximately $2\times10^{-4}$ cal per centimetre per second per deg. Cent.

The foregoing physical data are of importance to the heat-transfer function of the fluid, and if these values are inserted in the relevant formulæ[8] it will be found that "Pyroclor" is as effective a heat-transfer medium as mineral transformer oil—a fact which has been amply verified in practice.

*Pour-point.*—The pour-point of "Pyroclor," as determined by the method of I.P.40, is below − 32 deg. Fah.

*Vapour Pressure.*—The vapour pressure as a function of temperature has been measured by a boiling point method, and the results are shown in Fig. 7. The values are, in fact, those for

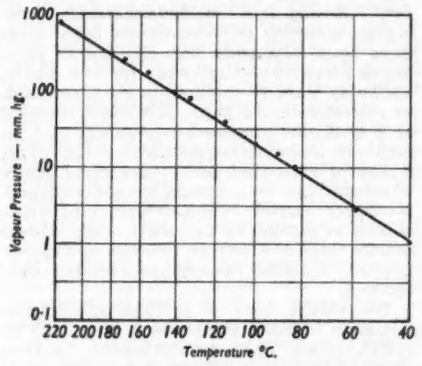



**Fig. 7—Vapour pressure of "Pyroclor" as a function of temperature**

trichlorobenzene, as would be expected from the physical properties of the two components.

*Bunsen Coefficient.*—This property has been determined for air over a temperature range by degassing a sample in an evacuated vessel, then admitting air to the vessel and measuring the volume absorbed. Bunsen coefficients for a range of temperatures are shown in Fig. 8. It is

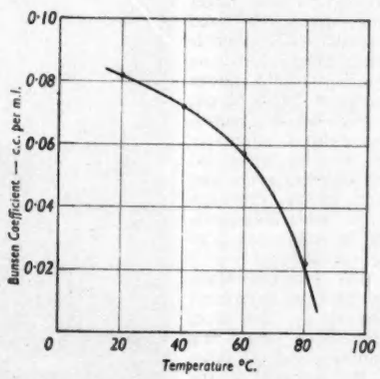



**Fig. 8—The air absorption of "Pyroclor" as a function of temperature**

seen that this coefficient diminishes with increasing temperature. These values are much lower than those for mineral oil. It is hoped to publish these results in fuller form elsewhere.

## Chemical Properties

"Pyroclor" has a greater solvent action than mineral oil. The fluid dissolves many of the insulating materials commonly used in mineral oil transformers, and care must be taken to check the resistance of all materials intended for use. A very wide range of products has been examined, and this aspect will be dealt with in greater detail in the concluding part of this article, to be published next week.

Chlorinated hydrocarbons of which "Pyroclor" is an example, have a remarkable degree of stability; unlike oil, they do not oxidise in contact with air. When heated with oxygen for forty-two hours at 140 deg. Cent. under a pressure of 250 lb per square inch, no chemical change occurs, the fluid remaining clear and neither acid nor chloride ions being detected.[3] No sludge, such as would be found in mineral oil, is formed, and in a typical case in practice it was found that after fifteen years' service the acidity had risen from less than 0·005mg to 0·03mg of KOH per gramme of fluid.[7] It has been general experience that far less servicing is necessary with "askarels," and this has encouraged the development of a sealed-tank design which is now popular in the U.S.A.

It has already been pointed out that hydrogen chloride is evolved when "Pyroclor" is subjected to arcing. This gas is not very soluble in the fluid (3cc to 5cc of gas per 100ml of fluid), but if water is also present, hydrochloric acid would be formed which would attack any cellulosic insulation and metal surfaces exposed to it.[7] In the event of minor arcing, therefore, it would be advisable to clean the fluid fairly quickly to avoid damage, but for the presence of a "getter" that is added to the basic blend by the manufacturers to absorb dissolved hydrogen chloride. Such a compound is termed a "scavenger," and in the case of "Pyroclor" it is present in the form of 0·125 per cent of tetraphenyl tin. This material reacts with the hydrogen chloride to form harmless benzene and complex tin chlorides which do not ionise in solution. Clark has dissolved hydrogen chloride in "askarel" with, and without, tetraphenyl tin present and then immersed manila paper in these samples of fluid[7]; a very considerable fall in the tensile strength of the paper occurred when no scavenger was present, but the paper which had been exposed to the "askarel" with the tetraphenyl tin showed no significant change. Childs and Stannett, at the research laboratory of the Central Electricity Authority have confirmed this result.[9] This additive has no other effect on the performance of the fluid.

## Effect of Water

"Askarels" are stable towards hydrolysis. If the fluid is refluxed with water, with oxygen passing through the mixture, no free chlorides are generated no matter how long the treatment; nor are chloride ions produced even if the liquid is sealed into a glass capsule together with water and heated for many hours at 150 deg. Cent.[3]

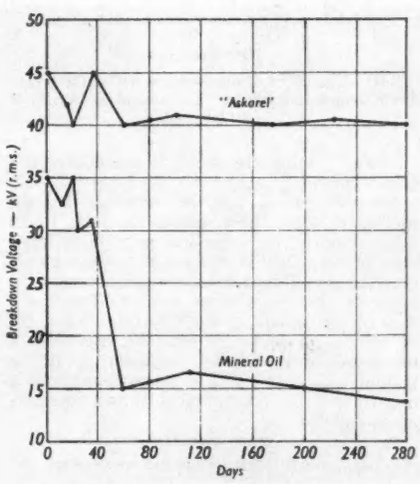



**Fig. 9—The effect on breakdown strength of exposing mineral oil and "askarel" to the atmosphere (A.S.T.M. method of B.D.S. test)**

In an atmosphere of high, but fluctuating, humidity, and exposed to sunlight, the liquid has been shown to maintain its high breakdown strength, even though water accumulated as a separate phase on the surface ; under the same conditions mineral oil gave a considerable drop in breakdown strength, as Fig. 9 shows.[10]

Water is actually slightly more soluble in clean " askarels " than in mineral oil, as Fig. 10 shows.

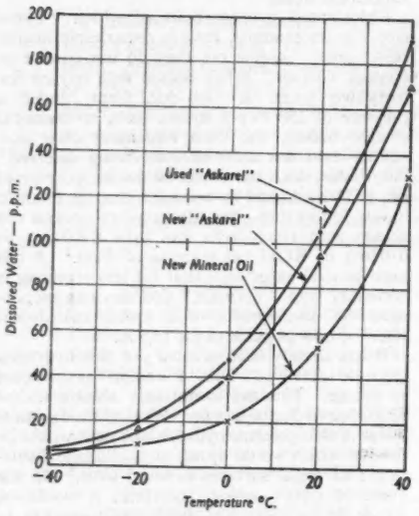



**Fig. 10—Solubility of water in " askarel " and mineral oil**

However, it is seen from this same diagram that there is little change in service. With mineral oil, water produced during the oxidation process can catalyse this process, whilst also facilitating acidic attack on the insulation and metallic parts. In extreme cases the oil can become emulsified, whereas true stable emulsions do not occur with " askarels." Clark has reported the effect of water solution on the breakdown strength of

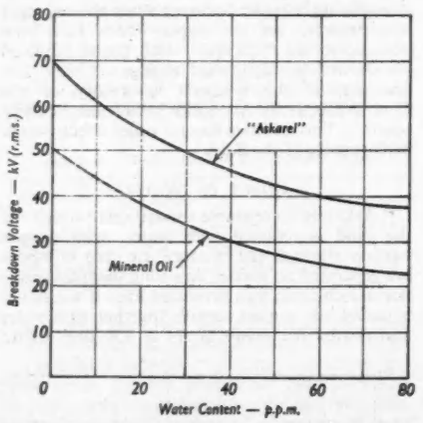



**Fig. 11—The effect of dissolving water on the breakdown strength of " askarel " and mineral oil (A.S.T.M. —0·2m gap)**

" askarel," using the A.S.T.M. method of test (Fig. 11).[11]

Dissolved water can be removed by the use of a paper filter press, the final traces being removed by spray-drying or earth treatment, using similar equipment to that commonly used for oil. Should moisture gain access to the inside of the tank in some way or other, it will float on the surface of the " Pyroclor " and not be carried by convection into the insulation of the transformer. Ideally, no water should be present. To ensure this, a design incorporating a sealed tank has been adopted by manufacturers in the U.S.A.

### Behaviour Under Conditions of Arc

The products of arcing have already been discussed in connection with fire-resistance and chemical stability, and it may be asked why " Pyroclor " should not be used to replace oil in oil-immersed switchgear, since fire hazard is by no means a negligible risk with such equipment. It cannot, in fact, be used, since it is not sufficiently arc-suppressive, and because of the evolution of hydrogen chloride. When an arc is struck corrosion problems would be introduced. For these same reasons on-load tap-changing gear under the surface of the dielectric cannot be used with " Pyroclor " transformers.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[3] Clark, F. M., *Journal of Industrial and Engineering Chemistry*, 29, 698 (1937).
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[10] Clark, F. M., (*Transactions of the American Institution of Electrical Engineers*), 56, 671 (1937).
[11] Clark, F. M., *loc. cit.*, 59, 434 (1940).

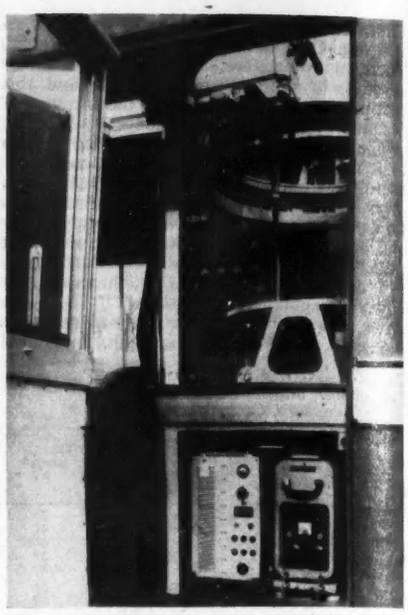

*(To be concluded)*

## "Roving Eye" Television Equipment

The engineering designs department of the B.B.C. recently gave a demonstration of a new " Roving Eye " equipment which incorporates a number of improvements based upon three years' experience with the first of these mobile television camera units. The new vehicle, known as Mark II, is shown in the photograph we reproduce on this page. It has been designed as a small, self-contained, two-camera unit, to fulfil the following requirements :—The transmission of a television picture and sound signals whilst moving ; for operation as a self-contained, two-camera outside broadcast unit ; the transmission of pictures at very short notice, and to provide additional camera channels in conjunction with a normal three-camera outside broadcast unit.

The vehicle used is a shortened Karrier " Bantam " chassis fitted with a body built to B.B.C. design. Extra accommodation has been obtained by making full use of the space above the engine and taking advantage of the absence of a partition behind the driver. Its equipment includes a " vision mixing " unit which permits the selection of the output of the required camera. Picture signals can be transmitted together with the sound programme signals to a fixed base whilst the vehicle is moving. A telescopic mast, which can be extended by pneumatic power to a height of 45ft, enables the equipment to be used over a very much larger range from the fixed base than was possible wih the previous "Roving Eye." A 6kVA power supply at 240V, 50 c/s, is provided by a petrol-engine-driven alternator set in a soundproofed compartment at the rear of the vehicle. Provision is also made for operating the equipment from the mains supply.

Two Marconi Mark IB image orthicon cameras are provided, one on a roof ring mounting and the other at the nearside of the vehicle alongside the driver. The traversing ring on which the roof camera is mounted is supported on an elevating device, the three screwed columns of



**This illustration shows the retractable mounting of the roof camera, vision transmitter in the background, test waveform generator and camera power supply in the bottom foreground**

which are rotated by a small electric motor through chains. With this device the camera can be readily raised from its stowed position inside the vehicle to its operational setting above roof level. The cameraman stands on a fixed platform set above the floor level of the vehicle as can be seen in the illustration above.

A vision mixing equipment can be used to fade out or cut from one camera to the other, or to mix the outputs of the two cameras. For use when the vehicle is operating from a fixed point a line-sending amplifier is installed for feeding vision signals by Post Office lines. Three-picture monitors are provided in addition to those in the camera control units. One of these monitors is set at the commentator's position by the vehicle. The other two monitors are mounted above the camera control equipment and include multi-channel receivers so that they can also be used for radio check. Provision is made for eight microphone channels. For normal broadcasting both of the cameras can be used up to 1000ft away from the vehicle, to which they are then coupled by cables. Alternatively, the whole of the apparatus, including the camera channel and sound and vision control equipment, can be removed from the

**" Roving Eye " Mark II television vehicle equipped with two cameras and arranged for transmission of picture and sound signals whilst moving**

vehicle and set up elsewhere, using a spare cable "harness."

Vision signals are transmitted from the vehicle to a base by a frequency-modulated transmitter, operating in the 610 to 660 Mc/s band and feeding a six-element "Yagi" array set at a height of 16ft when the vehicle is transmitting on the move. In order to keep the transmitting aerial accurately beamed on the base when the vehicle is moving, the array is controlled by a gyro-compass, which keeps it on a constant bearing through a servo-system. When necessary, the bearing of the aerial can be varied independently of the gyro-compass, to correct alteration of the bearing when changing position of the vehicle in relation to the base.

Sound signals are transmitted to the base by a frequency-modulated transmitter, using an omni-directional roof-mounted whip aerial, on a frequency in Band I. This radio link also carries an engineering control speech channel as upper-sideband modulation of a 10 kc/s sub-carrier, and a 15 kc/s sub-carrier which can be keyed for signalling. Another whip aerial receives a Band I signal from the base and frequency-modulated sub-carriers on this signal provide production "talk back," engineering control, signalling and a mains frequency signal for locking the waveform generator frame frequency to the "grid."

When the vehicle is not "roving," the "Yagi" aerial and the single whip aerial, serving both the transmitter and receiver on Band I, can be mounted on the 45ft telescopic mast considerably to extend the operating range of the equipment. For this purpose, a combining equipment is included to enable the Band I transmitter and receiver to share the whip aerial, and it includes a 60 dB rejector to prevent break-through from the transmitter to the receiver. The range of the equipment is about 2 miles when the vehicle is moving and about 10 miles when it is stationary and the high mast is in use.

## Teaching Device for Royal Navy

On Wednesday of last week, in the presence of naval representatives from many countries, Admiral Sir William Davis, the vice-chief of Naval Staff, formally set in operation the new trainer for the Royal Navy which is known as the "Action Speed Tactical Teacher." This training device has been designed by the Engineering and Materials Research Department of the Admiralty and has been installed at the Royal Naval Tactical School, Woolwich. The purpose of the teacher is to provide naval officers with the means to exercise and to acquire the tactical skill necessary to overcome situations liable to arise under active service conditions, and for this the apparatus reproduces the tactical operation of ships by electric and electronic means.

The installation consists of an auditorium, from which the control of the exercise is conducted by the staff, in association with a number of cubicles fitted out as control rooms to represent surface ships, submarines or aircraft. There is a total of sixteen ship cubicles, of which four may be aircraft carriers and six may be submarines, each equipped with a plotting table, a radar P.P.I., six communication lines and a ship control unit, as shown in our illustration. The latter incorporates speed, course setting and helm angle controls which enable the ship to be steered on any required course and speed, and can automatically cause the ship to zig-zag to any one of twelve pre-set diagrams. A total of twelve aircraft are housed in four cubicles, each having four communication lines, and each of the three aircraft in a cubicle is directed by an aircraft control unit which steers the required course and speed and transmits height to the air controller. The radar P.P.I. in the cubicle, which is shared by the aircraft, can be switched to any particular aircraft. All the radar P.P.I.s are arranged to select any one of five scales, which are namely 10, 30, 75, 100 and 200 miles.

In the auditorium, of which we reproduce a picture, are arranged the control consoles which accommodate one red and one blue controller, an air controller, a radio warfare controller and two weapon umpires for gunnery and torpedo actions. Various repeater dials and lights on the consoles inform the control officers as to the course, speed and radar state of each ship or aircraft, while a chief yeoman of signals, manning a signal console, deals with all W/T (morse) signals. Officers in the cubicles use the communication lines for passing all other signals. Map references giving the position of ships and aircraft are reported to the plots in the cubicles by two tellers. The controllers' display consists of a screen, measuring 12ft by 12ft, which can represent playing areas of 25 by 25 miles, 100 by 100 miles, 400 by 400 miles, or 1600 by 1600 miles, on to which are projected symbols representing ships and aircraft. Each unit has its own projector which displays the symbols on the screen, set on the correct course and which moves them along the course and at the speed determined in the cubicle as corrected for scale in the lining-up indicator. The weapon umpires can project on to the screen torpedo salvoes and anti-submarine searches, while to assist in assessing bearings and distances there are "spiders' webs" which can be centred as required by the controllers. In addition to the display screen there is another screen of the same size upon which an expanded radar picture can be centred as required by the controller, the scale of the picture being of either 50 by 50 miles or 100 by 100 miles, and independent of the scale in use on the main screen. Behind each white screen, which can be rolled up, there is a "Perspex" screen, behind which plotters track in, by means of coloured chinagraph pencils, the movements of ships and aircraft. These "Perspex" back screens are edge lit, but with this lighting switched off the tactical situation at any particular point can be displayed by fluorescent symbols on the screen illuminated by ultra violet lamps. It is possible for the whole "teacher" to operate at four times action speed if required by giving the clock impulses at 7½ seconds, instead of every half minute, so that the dials move at four times their normal speed.

For any particular exercise the officer students form two opposing teams, before each of which a tactical situation and an objective is set by the directing staff. Then, based on the data and intelligence thus given, the commander of each team formulates his plan of action. Cubicles are allocated to the students who, using the equipment provided, control the speed and course of their units, a record of which is automatically traced on the individual plotting tables. The communication lines, already mentioned, allow the students to receive and transmit orders and to plot the position of other craft. At the same time electronic coupling between the cubicles provides each student with a picture of the tactical situation, such as could be detected by the radar and asdic equipment of his own unit. Electric contacts from each control room cause the associated symbols to move according to the course and speed set, so that the director and his assistants can watch the tactical situation as it develops. At the conclusion of the exercise, the movements tracked on the "Perspex" back screen enable the manner in which it was conducted to be critically examined. The exercise held on Wednesday to initiate and demonstrate the operation of the "Action Speed Tactical Teacher" represented the defence of a convoy against submarine, surface and air attacks by means of a frigate escort, air patrols and air operations from an aircraft carrier. In addition to the Admiralty departments concerned the following were the main contractors: George Taylor and Co., Ltd. (wiring); Research Engineers, Ltd. (consoles, projectors and lining-up indicators); Technical and Scientific Packers, Ltd. (cubicles); E. Pollard and Co., Ltd. ("Perspex" screens, &c.); Redifon, Ltd. (radar system); Cinema Television, Ltd. (radar "blow up" equipment); Aeronautical and General Instrument Company, Ltd. (ship and aircraft control units); and Laurence Scott and Electromotors, Ltd.

EASILY CLEANED ROTARY PUMPS.—A new model of the positive displacement rotary pump made by Plenty and Son, Ltd., Eagle Iron Works, Newbury, Berks, has been developed to provide an easily cleaned pumping unit for the food, pharmaceutical and similar industries. These pumps can be supplied for handling between 33 and 90 gallons per minute of medium viscosity fluids and are made with stainless steel bodies, rotors and shafts. All that is necessary when dismantling a pump for cleaning is the loosening of four captive thumb screws and the extraction of the complete rotor assembly with a special tool.

(Left) A ship cubicle showing the plotting table, ship control unit, the P.P.I. and the communication lines. (Right) Auditorium showing in the background, the display screen to the left and radar screen to the right, and the various control consoles with the weapon umpire console with its projectors in the foreground

# Electronic Reading Automaton

*The pilot model of an electronic machine for reading printed or type-written characters has been built by Solartron Electronic Business Machines, Ltd. In its present form the machine is designed to read and recognise the numerals 0 to 9 at a rate of 120 characters per second, but it can be developed to handle other characters, and rates up to 500 characters per second are stated to be practicable. The machine, which is known as ERA (Electronic Reading Automaton), is capable of greatly increasing the rates at which information can be fed into computers.*

AN electronic machine known as ERA (Electronic Reading Automaton), designed for reading printed or typewritten characters, is being developed by Solartron Electronic Business Machines, Ltd., Goodwyns Place, Dorking, Surrey. In its present stage of development the pilot production model of ERA is arranged to read and recognise the numerals 0 to 9 and we are informed that it can do so at the rate of 120 characters per second. The system is, however, stated to be capable of being developed for operational speeds up to 500 characters per second, whereby a quarto sheet of double-spaced typescript could be read character-by-character in two seconds.

Such developments offer good prospects for widening the scope of computer applications, particularly to business procedure. For, if characters can be read and recognised at speeds like those quoted above, it should be possible to feed information into computers as rapidly as they can use it. At present, on the other hand, most electronic office machines and computers that can calculate and store or deal with information operate so rapidly that the useful work they can do is limited largely by the input and output facilities available. It is estimated, for example, that ERA can provide input information for a computer 144 times faster than a punch-card operator producing 300 cards per hour.

It should be emphasised that ERA is a rapid "character recogniser" but that it cannot store or treat the information it gathers. Its function is, simply, to convey the information it reads to any of the existing machines that are designed for dealing with the information. For example, ERA can be applied to the process of transferring, or "translating" typed or printed information into punched card or tape form. Where totals, partial totals, or other computations as with statistics, are required, ERA can feed directly into a modern electronic computer, which performs the required calculation. For the sorting of documents themselves, ERA can be associated with a high-speed sorter and programmed to look for the indexing serial or combination while disregarding the rest of the document. The simplest application is the recognition of the numerals 0 to 9 with some letters and plus and minus signs, but the system can be extended to apply to characters other than Roman.

The principle of operation of the electronic reader is to scan each character in turn to measure the proportions of black and white in successive areas of the raster, and to translate this optical information into electrical output information. In scanning each character the raster is divided up into 100 similar areas. In each of these areas either white or black will predominate and accordingly an appropriate "yes" or "no" signal will be sent out from each, to give 100 pieces of "yes" or "no" information about each character.

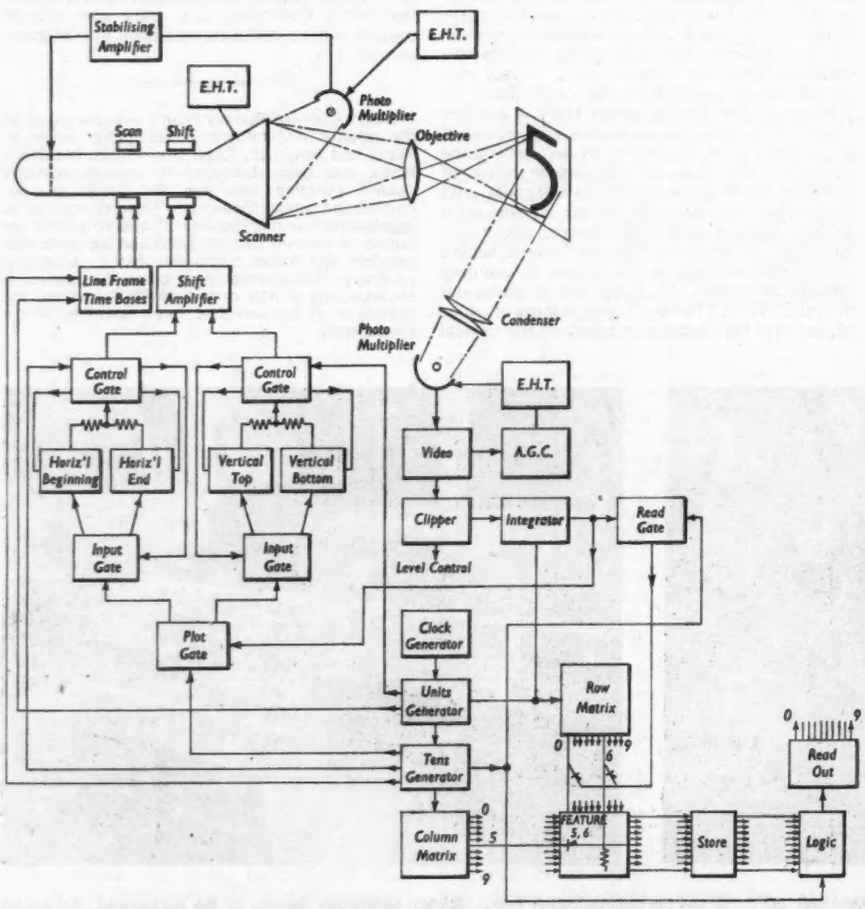



Fig. 1—Simplified block diagram of pilot model character recogniser for numerals 0-9

In fact, four such pieces of information would be sufficient to provide discrimination between each of the digits 0 to 9, together with six alphabetical characters. The 100 pieces of information, therefore, provide a profusion of redundancy, but this redundancy is made use of in ERA to eliminate unreliabilities in each separate piece of information. Thus, because of blurring, paper texture, and play in the operating levers no two imprints from the same machine (typewriter or computer printer) are identical; still more serious discrepancies exist between figures from different machines. ERA makes use of a large proportion of the available redundancy to counteract the effect of imperfections and deviations. A simpler use of redundancy to remove uncertainty of information is, of course, the repeating of a telegraphic message in the same or different phraseology in cases where the text is liable to corruption in transmission. The pilot model of ERA is illustrated, at the makers' works, in Fig. 2, on the left of which is the scanner (shown in more detail in Fig. 4). In Fig. 3, we show a rear view of part of the character-recognition circuits.

With reference to the simplified block diagram of Fig. 1, the operation of the electronic reader is briefly as follows. A raster of vertical lines is produced on the face of the scanner tube (Fig. 4) by means of the deflection circuits. A photo-objective is employed to obtain an image of the raster about the character to be "read." As the image of the scanner spot scans a character the light reflected at any instant is proportional to the luminance of the reflecting surface, i.e. the white paper will reflect more light than a black character. A photomultiplier tube of high sensitivity converts the reflected light to video pulses, which are, in turn, amplified and "cleaned up" in the video amplifier and clipper respectively.

In this scanning process, which divides the total area into 100 similar areas, any misalignment of the raster could give a false result. Some misalignment can be compensated in the "and/or logic" circuit which is described below. Where severe misalignment may occur, each character is scanned twice; once to correct misalignment, and once to read it. In the first scan, its top is observed, then its bottom left and right extremes; each is divided by two, and in the subsequent scan a pair of $X$ and $Y$ shifts put on to bring its centre to the centre of the character. In more detail, the position of the first and last lines which have any black content, are counted horizontally on a staircase counter. Half the difference gives the shift required. Vertically, a similar process with unit lengths instead of lines is used. This part of the cycle is called "registering" to distinguish it from "recognising."

A timing pulse is required to keep the scanning and recognition processes in step. The clock pulse generator (Fig. 1) develops a basic pulse time of two microseconds. From this an eight microseconds pulse is obtained (feature period) plus four microseconds blank period between features. Ten periods are used for the character. The line feature is extended one feature at the top and bottom to allow for character misalignment. Two feature times are used for flyback.

The raster for registering is required to be twice as fine as that for reading. To save "circuitry" at not much cost in cycle-time, the raster is always allowed to run at fine pitch, and inhibit reading during every second line. After this two-divider, the "unit feature" and "tens of features" generators "gate" each black or white signal through a 100-way electronic switch into its appropriate position in the 100-feature stores. At the end of a "read" stroke the store is filled.

The process of "decoding" the information contained in the store and identifying the character scanned is carried out in what is called a logical matrix. This logical matrix is composed of diodes pre-programmed to give what is known as "and/or logic"; that is to say, to respond either when, say, features $x$ or $y$ or $z$ are stored black ("or-logic"), or when features $x$ and $y$ and $z$ are stored black ("and-logic"). Black and white criteria can be mixed in any stage of the logic. If matters are so arranged that the potential is changed on an "out" wire when any diode of a set from various "in" wires

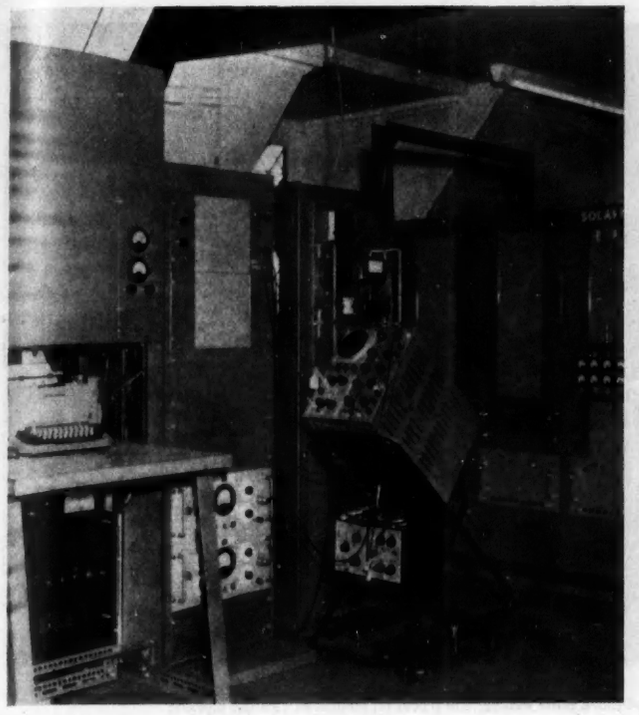


Fig. 2—Pilot model of electronic reading automaton. On the left is the character scanning assembly with a typewriter below it. The cabinets on the right contain the character-recognition equipment

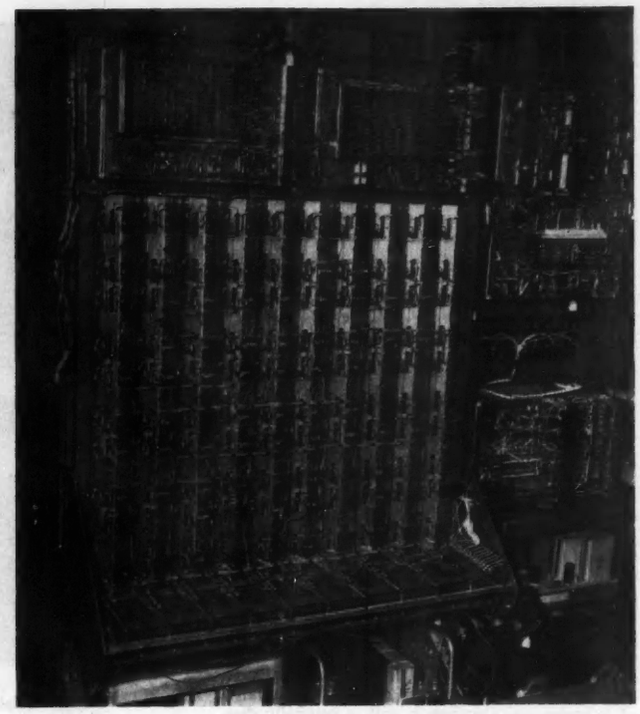


Fig. 3—Rear view of part of the character-recognition equipment of the electronic reading automaton. The banks of electronic switches constitute the column and row matrices shown in the block diagram, Fig. 1

conducts, an " or " circuit is made ; if the potential cannot change till every diode stops conducting, an " and " circuit is made. In simplified form the " and/or logic " consists of a series of little groups or statements such as : " if black is (either in 12 and 13 or 32 and 33) and is in 22 and 23, but is not in 37 or 38, the character is 4." In practice the statements are somewhat more lengthy.

The primary output from the logical store consists of pulses corresponding to the numerals, one per wire. These pulses can directly operate a keyboard or sorter. For feeding a computer directly, the numerals can be stored each in binary form in a temporary store, which is then gated serially by clock-pulses from the computer. The output is then in binary-decimal form (or with other moduli for shillings and pence, for example), with which contemporary computers can operate. The time-clock can be synchronised by a computer to make the read-time a submultiple of the computer's clock time. With additional units, standard addresses can be added to each set of numerals for appropriate processing. To correct for progressive " creep " in reading a long document such as a paper roll, the smoothed component of the correction output is available as a servo signal.

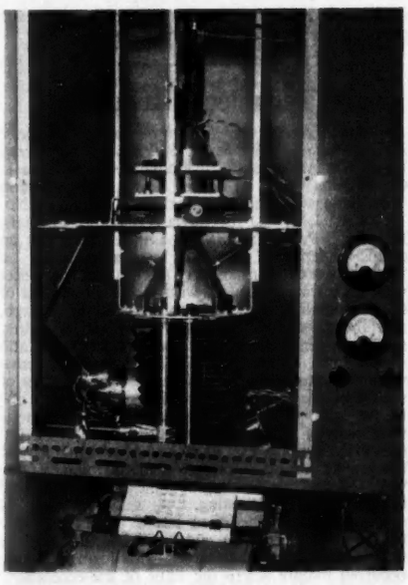


Fig. 4—The character scanning assembly of ERA is shown here (with covers removed) scanning typewritten numerals

# Industrial Glass Pipelines

THE use of glass pipelines in the chemical, food, drink and other branches of industry has been steadily growing for some years, and to meet this demand James A. Jobling and Co., Ltd., Wear Glassworks, Millfield, Sunderland, has introduced new techniques to increase output of visible flow pipelines in " Pyrex " brand glass. An associate company Q.V.F., Ltd., has been formed to market this glass pipeline, and is a member of the Triplex group of companies. To further supplement output a new factory has been built and equipped at Pallion about a mile from the parent works. This new factory receives the glass pipe in the manufactured state from the parent works and is mainly concerned with the actual fabrication of pipeline sections for installation ; it is stated to be capable of turning out more than 5 miles of pipeline a day. In the course of a recent visit to Sunderland we were given an opportunity to see these two glass works.

Glass manufacture is believed to have started at Sunderland in about A.D. 674 and by the middle of the nineteenth century there were nine glass making concerns in the area. One of the principal works—the Wear Flint Glassworks—was acquired by James A. Jobling in 1885. In 1921 the firm acquired the patents for the manufacture of " Pyrex " heat and chemical-resisting glass from the Corning Glassworks of the United States and has been making it in increasing quantities ever since. This is a borosilicate glass of low alkali content, containing no elements of the alkaline earth group and no zinc or heavy metals. It is highly resistant to the attack of water and all acids, with the exception of hydrofluoric and glacial phosphoric acid. Its low coefficient of thermal expansion also enables " Pyrex " industrial glassware to withstand a high degree of thermal shock.

Before dealing with the actual production of the pipelines some general particulars of the processes followed in making glass and the laboratory and other glassware produced in the Wear works are worth recording. The basic ingredients of the glass are a pure iron-free sand mixed with " cullet "—which is glass broken down for re-melting. The materials, about 70 per cent sand and 30 per cent cullet, are batched and mixed in a special shop before being fed automatically at a controlled rate into the glass making furnaces. These furnaces of about 120 tons capacity are maintained at a temperature of 1600 deg. Fah.

For the manufacture of mould blown flasks and cylinders a platform a few feet above floor level is built round part of the furnace. At a number of points access holes are provided in the furnace wall from which a " gatherer " picks up a globule of molten glass on a blowing tube and passes it to glass blowers at the side of the platform. These blowers first blow the general form of the required article, which is then lowered into a mould, at floor level beside the platform, in which it is finally blown out to the required shape. The articles are then passed into a separate shop where the excess glass left in the blowing operation is cut off and the edges formed on machines, prior to annealing in continuous ovens. The many kinds of tubes and other integral attachments to the flasks and tubes are fused on in a separate department by highly skilled glass blowers. A vast amount of interesting and intricate glass ware is produced and a typical example of the precision work is the manufacture of " Oldershaw " columns. For these columns 1in or 2in diameter tubes have fused and sealed into them a series of thin perforated glass baffle plates incorporating distance pieces. These plates are drilled with a hundred or more very small holes in a predetermined pattern. They have to be fused round their edges into the glass column without undergoing any distortion or closing of the holes. It would normally be expected that such complicated assemblies would be produced under special conditions in a development section, but techniques have

been introduced to enable the manufacture of the columns under a normal glass shop procedure at a commercially economical price.

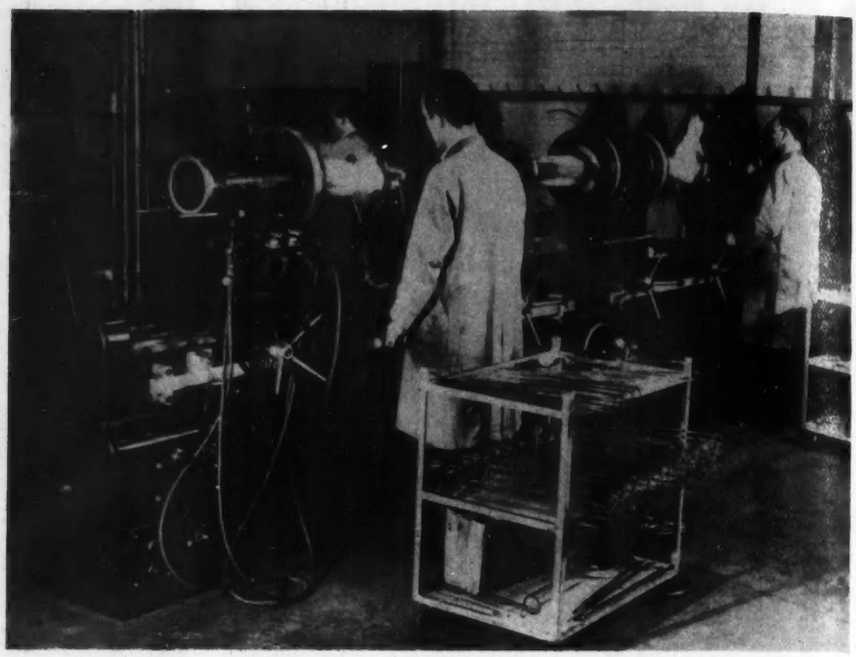
The production of glass pipeline is by a continuous automatic drawing process at one side of the furnace. For this purpose a stream of molten glass is fed continuously from the furnace into a rotating fore-hearth or bath to maintain a constant level. From this hearth a continuous run of glass tube is drawn upwards as it is formed in passing over a central cone of the required bore size, which projects above the level of the molten glass. A flow of hot air passes into the tube as it is formed above the cone, and the glass cools and sets as it is drawn up some 70ft in a tower. At the top of this tower tubes of the required lengths are cut off and passed into an inspection section and stores. The continuous tube drawing plant is designed for the manufacture of tubing from ¼in to 5in diameter, the drawing speed of the largest diameter being in the region of 2ft per minute, with proportionally higher speeds for the smaller sizes. The very large tubes, which can be up to 18in diameter, are not suited for production by continuous drawing and are mould blown.

The demand for precision glass tubing has steadily increased during recent years for use in many forms of instruments, measuring and other apparatus, and for its production a group of special drawing machines has been laid down at the works. On these machines tubes can be drawn to within 0·01mm of a specified internal diameter and 0·025mm of the required outside diameter. Each machine consists essentially of a horizontal drawbench with a centrally disposed tunnel heating zone. As the tube is drawn through this zone it is heated to the plastic state. By the application of vacuum to the ingoing side the plastic section of the tube is drawn down on to a precision mandrel suspended in the bore and the drawing speed is so regulated that the glass sets just as it clears the end of the mandrel. Precise control of the temperature, speed of drawing and mandrel size combine to give the required reduction to the specified diameter tolerances.

As already mentioned all of the industrial visible flow glass pipeline work of the company is now carried out at the new Pallion factory. This factory covers an area of some 25,000 square feet and a general impression of its main production area is given in one of our illustrations. Generally glass pipelines are built up of 10ft lengths of tubing coupled together by mechanical clamps, which lock on a short conical section of increased wall thickness at each end of a pipe. A number of special machines have been installed at the new works for the purpose of butt welding the moulded conical clamping sections on to the ends of tube lengths as received from the Wear works. In welding on these tapered sections it will be appreciated that a close control must be maintained to ensure concentricity without obstruction in the bore, final length of finished pipe, and parallelism of the ends. It is stated that on a normal 10ft pipe the overall length is within ¼in and that the faces at each end are parallel to within 0·088in.

The lathes used for this form of tube welding are fitted with two headstocks which can be rotated at the same speed, one headstock being fixed and the other slidable along the bed. The parts to be joined, such as a glass tube and moulded conical or other required end pieces, are mounted in the headstock chucks and as they are rotated they, together with the pipes, are heated to fusion temperature and brought together by inwards movement of the moving headstock. An electrical welding process developed a few years ago is used on the machines, and by it a quick local heating of the glass to fusion temperature is effected over a small area after preheating by gas burners. The process is based upon the fact that above a preheating temperature of about 350 deg. Cent. the insulating properties of borosilicate glass decrease, and its conductivity increases as the temperature rises. The preheating gas burners are used as electrodes during the actual fusion operation.

For making long lengths of pipeline the lathe fitted with three headstocks and shown in the illustration above has recently been installed. This machine has an 18ft bed and each of its headstocks is movable, so that it can be used as two independent lathes or as a single machine for welding long pipe lengths. Other equipment installed includes grinding machines for truing the faces of the moulded conical coupling pieces before they are welded to the pipes, and machines for grinding the plug-to-barrel faces on large glass stopcocks which are made in large numbers in this works. For annealing glass assemblies after welding two electric and one gas heated ovens have been installed. To ensure that all parts have been completely stress relieved before they are released for packing and despatch they are checked on polariscope equipment.



Triple-headed lathe welding end pieces on lengths of straight pipeline

Production floor of works manufacturing visible-flow pipelines

## Technical Report

*Recherches sur le Flambement de Colonnes en Acier A37, à Profil en Double Té, Sollicitées Obliquement.* By F. Campus and C. Massonnet. Travaux de la Commission pour l'Etude de la Construction Métallique, Comptes Rendus de Recherches No. 17. I.R.S.I.A., 53, rue de la Concorde, Brussels, Belgium. Price Fr. 175—The paper describes an extensive series of buckling tests carried out on "I"-section columns of A37 steel. The test pieces were eccentrically loaded, with the line of action of the compressive force being in the plane of the web, and the ratio of eccentricity to radius of central section ranging from 0·5 to 3; the slenderness ratio varied from 40 to 175. Preliminary experimental work was carried out to determine the properties of the material and particularly the residual stresses due to the rolling process. The actual buckling tests were carried out using oil-pressurised spherical supports. Failure took place in the great majority of cases after plastic deformation in the plane of the web, followed by buckling at right angles to the web accompanied by twisting. A small number of specimens, however, failed under excessive plastic flexure of one or both ends, with buckling of the flanges during the final stage. This form of failure occurred mainly where the signs of the eccentricity at both ends were opposite. The theoretical treatment takes into account both the importance of simple practical formulæ and the need to represent as accurately as possible the actual results.

# Progress of Modernisation Plans on British Railways

THE programme of improvements and re-equipment to be carried out during 1957 on British Railways was announced at a conference last week by Sir Brian Robertson, the chairman of the British Transport Commission. Sir Brian pointed out that more than a third of the £1200 million it was proposed to spend on the fifteen-year modernisation plan for the railways had now been committed to developments in progress or authorised. The individual programmes of expenditure already authorised include £92,000,000 for electrification; £33,500,000 for diesel locomotives; £32,500,000 for diesel multiple-unit trains, and £46,000,000 for major track, junction and station works.

### Electrification

It is expected that of the £92,000,000 authorised for electrification work there will be an expenditure of about £7,500,000 in 1957 and £11,500,000 in 1958. These sums do not include expenditure on new rolling stock, which will be in the region of £16,000,000 on new electric locomotives and multiple-unit trains. Twenty locomotives are planned for 1958, and 230 multiple-unit coaches in 1957 and 800 coaches in 1958.

The Commission considered that it should be possible to complete well before 1970 most of the electrification projects included in the plan and already announced. Since there should thus be the capacity to undertake additional electrification during the later 1960s, consideration is now being given to further electrification schemes.

Planning for the electrification of the line from Fenchurch Street to Tilbury and Southend is continuing. Work on some of the extensive preliminary engineering works in the neighbourhood of Barking is already in hand, and authority has now been given for the provision of facilities at Ilford, East Ham and Shoeburyness, for the repair, inspection and cleaning of the electric stock, and the provision of clearances for the overhead equipment between Fenchurch Street and Upminster. The total estimated cost of this scheme is nearly £20,000,000, and it is expected that it will be completed in 1961.

Work is starting this year, and will be finished next year, on the electrification of the lines from Colchester to Clacton and Walton, which will be used as a proving-ground for electrical overhead and signalling equipment on the 25kV a.c. system, now adopted as standard for future electrification of British Railways. A start has also been made on preliminary engineering work in connection with the electrification of the Eastern Region suburban line from Liverpool Street to Enfield and Chingford, Hertford and Bishop's Stortford, estimated to cost £6,500,000, and expenditure of the order of £1,500,000 will be incurred in 1957 and 1958. Completion of this scheme is scheduled for 1960.

Preliminary work on track, bridges, and tele-communications is in progress for the electrification of the Manchester-Crewe line. This pilot scheme for the electrification of the main lines between London, Birmingham, Liverpool and Manchester, is provisionally estimated to cost £10,000,000 and is programmed to be brought into operation in 1959.

About £1,500,000 will be spent in 1957-58 on Stage I of the Glasgow suburban electrification (Airdrie-Helensburgh, including Milngavie and Balloch Pier; Cathcart Circle; Cathcart East Junction to Kirkhill and Neilston High); and it is expected that these works will be completed in 1962. About £7,000,000 will be spent in 1957-58 on Stage I of the scheme for the extension of the Southern Region electrification, covering the lines from Gillingham, Maidstone East and Sevenoaks to Sheerness, Margate, Ramsgate, Folkestone, and Dover. It is expected that the work will be completed in 1962, but it is hoped that electric services will be introduced on some sections in 1959.

### Diesel Traction

A scheme has been approved for the construction of five diesel-electric trains to operate between London and Manchester (London Midland Region); between London, Birmingham and Wolverhampton; and between London, and Bristol (Western Region). Twenty-two lightweight diesel railbuses are being ordered, for delivery in 1957 and 1958, for experimental use in rural areas.

The first fifty of the 230 diesel main line locomotives, now on order or authorised at a total cost of £16,000,000, are expected to be delivered in 1957; over 100 are expected in 1958. Supplementary programmes for 1958 are also being considered. There are at present some 550 diesel shunting locomotives in service and a further 500 will be delivered during the two years under review. More than 1000 vehicles for use in multiple-unit diesel trains are expected to be delivered in 1957, and over 1200 in 1958 and by the end of next year, about 2700 will be in service. Deliveries of new passenger carriages for locomotive haulage are expected to be about 1300 in 1957, and 700 in 1958, the total cost (including also about 1800 non-passenger coaching vehicles) being £21,000,000.

### Freight Vehicles

Rapid progress is expected during 1957-58 with the programme for installing continuous automatic vacuum brakes on all freight wagons. In addition to equipping all new general merchandise wagons and 25,000 existing wagons, some 6000 new 16-ton mineral wagons will be fitted in 1957, after which all wagons built will be fitted with continuous brakes. The 1958 programme also covers the conversion of about 80,000 existing wagons to continuous braking and it is hoped to complete the programme in less than the ten years originally planned. Other features related to the general adoption of vaccum brakes which are now being closely studied include the development of an automatic coupler for vacuum-braked wagons; brake-maintenance and testing facilities; and the fitting of heavier wagons with roller-bearing or other improved axle-boxes.

During the two years under consideration it is expected that some 109,000 new freight and service vehicles and 13,680 new containers costing about £66,000,000 will be delivered to the railways.

### Junction, Yard and other Works

A number of important schemes for new or improved marshalling yards, relief lines, and freight terminals will be started or carried forward in 1957-58. A start will be made in 1957 with the construction of a flyover bridge south of Bletchley station, Bucks, at a cost of some £1,600,000. This flyover forms part of a wider plan for diverting cross-London freight traffic to routes which avoid the congested London area altogether. A new flyover is also to be provided at Rugby at a cost of £870,000 to obviate conflicting movements at the junction immediately north of the station, which will increase with the introduction of the more intensive main line electric service between London (Euston), Manchester and Liverpool. This work will be started in 1958, when it is also expected to put in hand the construction of a flyover at Euxton (between Wigan and Preston)—estimated to cost £320,000—where similar difficulties arise.

### New Lines for Freight Traffic

New connections are to be provided at Fenny Compton and Stratford-upon-Avon between the former G.W.R. and L.M.S. lines, which, in conjunction with new sidings at Honeybourne, will reduce congestion and enable traffic to be worked more economically. A new double line connection between Craiglockhart and Slateford (Edinburgh), to cost £700,000, which will be started in 1957, will considerably facilitate the working of coal traffic from Lothian collieries to the west.

In 1958, it is proposed to undertake the completion of the four tracks between York (Skelton) and Northallerton in the North Eastern Region, by the construction of an up slow line from Pilmoor to Alne. In addition, colour-light signalling will be installed on the slow lines between Pilmoor and Thirsk. This will facilitate the working of traffic over the main line and will make possible the diversion to the main line of freight trains from the Leeds-Harrogate-Northallerton line.

Important projects in South Wales have recently been approved at a cost of nearly £2,000,000. The capacity of the line between Pyle West Junction and Briton Ferry is nearing saturation point, and increased traffic will be arising in the near future from the developments of the National Coal Board and the Steel Company of Wales. Multiple-aspect signalling will be provided throughout the area, with two-way working through Port Talbot (General) Station, which will be reconstructed.

Good progress is being made with the schemes for new marshalling yards at Temple Mills, Ripple Lane (Barking), and Edinburgh (Millerhill). Work on a number of other yards to be put in hand in 1957-58 includes a new yard at Perth, which will replace the present four.

By the end of this year contracts totalling over £8,000,000 will have been placed for signalling installations. Among major re-signalling schemes, colour-light signalling is to be installed at St. Pancras at a cost of £294,000, and will be largely completed in 1958. The new signalling at Newcastle, involving the replacement of three signal-boxes by a single box, will also be completed in 1958, as will a scheme of colour-light signalling at Huddersfield. Other important signalling schemes are at Glasgow Central (to start 1957); Birmingham (Snow Hill), which is expected to be completed in 1959; and, in connection with the installation of multiple-aspect colour-light signalling between Paddington and Southall, the concentration of signalling at Old Oak Common in one signal-box, and similarly at Acton.

Schemes are being prepared for colour-light signalling between Newcastle and Berwick, and between Bentley and Leeds (North Eastern Region), at a cost of some £3,000,000. It is expected that work will start on these schemes in 1958, and it is hoped to start a scheme for centralised train control between Perth and Inverness at a cost of about £1,000,000 in 1958.

Detailed planning is now well advanced for the extension, to be completed by 1962, of the B.R. standard system of automatic train control to five principal main line routes: from London (King's Cross) via Newcastle to Edinburgh; London (Euston) to Glasgow (including Manchester and Liverpool); Edinburgh to Glasgow; London (Waterloo) to Bournemouth and Exeter; London (Liverpool Street) to Norwich.

## European Congress on Ground Movements

A CONGRESS for the discussion of problems of ground movement due to mining is to be held at the University of Leeds during the period April 9–12. The subjects selected for papers and discussion at the congress are grouped thus: surface movement; underground movement; laboratory tests and theory. Over twenty papers are to be presented at the congress covering the three main subjects as they are experienced in the principal mining areas of Europe. Apart from the technical sessions, there will be a reception and cocktail party, given by the University, and also an exhibition of surveying and geophysical instruments and drawing office equipment. The initiative for the congress came, we are informed, from a meeting of experts on this subject held at Heerlen in Holland in 1955. The British papers to be presented include, "A General Survey of the Ground Movement Problem," by Professor J. T. Whetton, "The Minimisation of Surface Damage by Special Arrangement of Underground Workings," by K. Wardell, and various other contributions.

# Nuclear Reactions and Power Development

*In the Boyle Lecture to the Oxford University Scientific Club, Sir John Cockcroft described what he called "a time spectrum of reactors for power development, extending into the far distance." In the following abstracts from the lecture, we include Sir John's remarks on research into the "fusion reaction" as a means of producing power.*

IF we look further ahead we can foresee a continued improvement in the performance and output of our gas-cooled graphite-moderated reactors. In particular, fuel temperatures are likely to be increased and so thermal efficiency and output will increase. So it is not at all unlikely that we shall see power stations with electrical outputs of 800MW and 1000MW. These very large outputs will have the advantage of reducing the number of sites which will be required. Because of the large amount of cooling water which will be required, the sites will be limited mainly to coasts and estuaries. But this would be so even for large coal-fired stations of the future.

Other types of nuclear power stations are possible. The U.S. is putting most of its effort and money into the development of water-moderated reactors, in which ordinary water surrounds fuel elements consisting of uranium oxide sheathed in an alloy of zirconium. Such reactors will only react if the uranium fuel is "enriched." The proportion of U235 must be about 50 per cent above the normal content. So the uranium fuel costs rather more than three times the cost of natural uranium. The cost of sheathing in zirconium alloy is also high. So fuel costs are at present very high—about equal to our total power costs at the present time. They are, however, expected to be reduced by metallurgical development. The capital costs of this kind of nuclear power station are likely to be appreciably lower than those of our first electricity authority power stations, because they are smaller; the reactor drum is 10ft in diameter instead of the 35ft of Calder Hall.

At Harwell we are working on more advanced types of nuclear power stations. One of these aims at working at appreciably higher fuel temperatures—of the order of 800 deg. Cent.—by using ceramic fuels. It would also provide inherently higher outputs per unit volume, which is good for reducing capital costs. We are at present working on its technology, which is an indispensable preliminary to all reactor development. For example, samples of the fuel elements have to be tested in so-called "loops" in our research reactors BEPO and DIDO. These loops are complicated test equipment. They contain the fuel element samples, and past them circulates gas of the same kind and at the same temperature as that to be used in the final reactor. The loops are run continuously for months, and then the fuel element is removed in a highly radioactive state and examined behind lead walls by remote handling equipment. Simultaneously with operating loops, we design the first reactor experiment, and this normally takes about two and a half years to design and build. The reactor experiment allows us to obtain experience of all the operating problems of new types of reactor and the nuclear physics behaviour and the kinetic behaviour of the reactor. If the reactor experiment is promising, the next step is to design and build a prototype reactor, which is probably a small-scale version of the later full-scale commercial models.

We are also building an experimental fast neutron breeder reactor with the long-term objective of making much greater use of our uranium fuel supplies. Our first "electricity authority" reactors will extract the heat equivalent of 10,000 tons of coal for each ton of uranium. In principle, however, it is possible for breeder reactors to do 100 times better, because the breeder can burn the abundant U238 or thorium. We started this development by building two so-called "zero energy" reactors, ZEPHYR and ZEUS, fuelled by plutonium and U235 respectively. Inside ZEUS there is a core consisting of rods of U235 surrounded by a "blanket" of natural uranium. The chain reaction starts in the core and surplus neutrons are captured in the blanket to produce Pu239. Some of the fast neutrons also produce fission in the blanket. In the ZEPHYR reactor, which has plutonium fuel, more than two new fissile atoms are produced for each fissile atom destroyed. We say the "breeding gain factor" is over 2. The fact that the neutrons are slowed down as little as possible means that the capture and loss of neutrons by structural materials is small. In a full-scale fast reactor fuelled by plutonium we might expect a breeding gain of 1·6 to 1·7.

The fast reactor is therefore the nuclear physicist's dream. On the other hand, it presents severe problems to the engineer. For the core of the reactor is small, being fairly concentrated plutonium or U235 contained in a cylinder of about 2ft diameter. From this small core the equivalent of about 60,000kW of heat has to be extracted in our first experimental model which is now being built at Dounreay. The heat developed in the core is removed by circulating liquid sodium—chosen because it slows down neutrons very little. The liquid sodium passes through twelve heat exchangers arranged in parallel. Surrounding the whole reactor is a great sphere to provide a safeguard against any release of radioactivity. This reactor is due for completion in 1958.

I have described what might be termed a time spectrum of reactors for power development, extending into the far distance. I would like finally to look still further ahead and speak briefly about the possibility of using the reaction between the light elements—the so-called "fusion reaction" to produce power. The objective is to make use of the nuclear reactions between two deuterons or between a deuteron and a triton to release energy. You may remember that these nuclear interactions were discovered in the Cavendish laboratory during the golden age of nuclear physics of 1932/3.

It is well known that the stars derive most of their energy from the reactions between the light elements. As temperatures increase due to gravitational contraction, the velocities increase, and penetration of the nuclei can occur at increasing rates. The temperature must be very high for fusion reactions to go and particle densities must be reasonably high.

A fusion reactor must provide a source of energy to heat the gas to the reacting temperature. It must also provide a means of containing the hot gas so that losses of heat by radiation, conduction and convection do not far exceed the heat input. If we look at the radiation processes first and were to assume radiation equilibrium, then the usual black body relationship would give a radiation flux of $10^{m}$W per square centimetre at $10^{8}$ deg. However, radiative equilibrium is far from achieved. A complete calculation of energy losses shows that since the reaction rate increases very rapidly with temperature, and the radiation rate increases as $T^{\frac{1}{2}}$, the power produced may exceed radiation above a certain temperature.

The important question is how we can both heat up and contain the hot reacting gas. Experimental work on this subject started in the Clarendon laboratory in Oxford under Dr. Thonemann in 1948 and a little later in Imperial College under Sir George Thomson. The principle of one method is to heat the gas by a powerful transient electrical discharge from condensers, and to constrain the plasma by magnetic fields. Fortunately the experimenter is helped by the well-known pinch effect, whereby the magnetic field of the current itself squeezes the discharge into a narrow filament. This effect can be helped by superimposed magnetic fields.

Experiments of this kind carried out in straight tubes were described by the Russian physicist Kurchatov at Harwell last May. A powerful discharge carrying 1,000,000A was produced by a condenser bank. The discharge was observed to contract and expand again. The experimenter observed X-rays of about 500,000V energy and neutrons were observed on the second contraction of the discharge channel. At first, the Russians thought they were observing a true thermo-nuclear reaction, but on further investigation they decided, for several reasons, against this interpretation of the neutron production.

At the Clarendon laboratory work also started on discharges in straight tubes, but later work, and all work at Harwell, has been concentrated on producing these pinched discharges in toroids, since this avoids the troublesome problem of having electrodes which naturally get very hot under these powerful discharges. An account of these early researches has been published in a series of papers to the *Proceedings of the Physical Society* (B January, 1957).

One of the papers, by Carruthers and Davenport, describes one of the troublesome characteristics of these ring discharges. The discharges turn out to have a very powerful instability characterised by wriggling of the discharge in the confining torus. A very simple explanation of this is that if the filament turns itself into a helix the magnetic energy is increased. So it naturally strives to become a helix. Fortunately, there is an opposite effect, predicted also by classical physics, which helps. As the wriggling filament approaches the walls of the tube, eddy currents in the metal tube walls tend to repel the filament. These effects were investigated at Harwell in a glass torus 10cm bore and 30in mean diameter, which heated the core by a large pulse transformer. Currents of 1500A were produced in argon and xenon at pressures of 1mm to $5 \cdot 10^{-5}$mm Hg. The discharges were observed with an electronically gated image converter which enabled photographs of 8 microsecs duration to be taken at any desired moment during the pulsation.

The experimental programme consisted of observing the phenomena in such ring discharges; in particular, measuring temperature as a function of current and pressure. Temperatures are measured by classical spectroscopy methods using the Döppler broadening to measure ion temperatures. Electron temperatures are measured by microwave techniques. This field of research is a fascinating example of the rapid and recent growth of magneto-hydrodynamics—the interactions between magnetic fields in the motion of matter—which is of great importance in stellar phenomena.

We are now at the same stage as fission research was in 1940, when the possibility of a chain reaction was well understood, but many uncertainties remained, and a further fifteen years elapsed before large-scale nuclear power was developed. It is certain, however, that there is a fascinating field of research ahead.

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NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—On February 22, Commander A. D. Bonny, R.N. (ret.), delivered his paper "Modern Marine Steam-Turbine Feed Systems" before the North East Coast Institution of Engineers and Shipbuilders. The paper states that depending on the auxiliary load, the method of auxiliary drive and the amount of regenerative heating employed, a range of 10 per cent in fuel rate is found in analysing a number of tanker designs of similar power. Even in a specific design with given loads, alteration to the auxiliary drive and feed heating can alter the fuel rate by 6 to 7 per cent. In the paper, the methods of auxiliary drive are examined and the use of regenerative heating is evaluated, and these are combined to give a "cycle ratio" which affords a useful criterion of the efficiency of the system. The cycle ratios of a number of feed circuits are compared and their relative first costs examined. Although generally more efficient than simpler ones, the more complex cycles cost more and so savings are reduced. It is stated that, although fairly simple, cheap and efficient, cycles can be evolved, the quest for simplicity may lead to an increase in the fuel rate and, hence, an appreciable increase in cost when taken over the life of the ship. Appendices to the paper give analyses of feed circuits.

## Diesel-Mechanical Shunting Locomotive

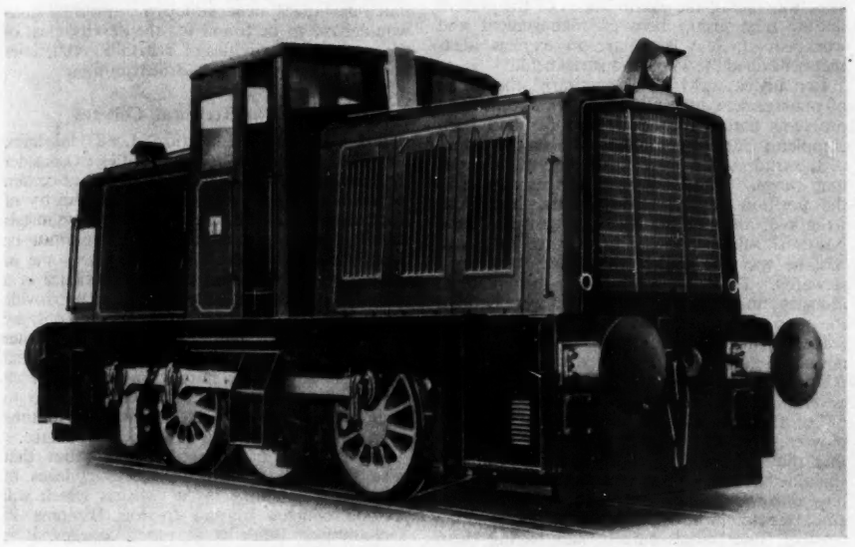
A NEW design of industrial diesel-mechanical shunting locomotive, developed by Ruston and Hornsby, Ltd., is intended for heavy-duty work in collieries, docks, power stations and similar establishments where heavy traffic is involved. The first of these locomotives has now completed just over a year of successful service at the Drakelow power station of the Central Electricity Authority, where the second of the locomotives has just been placed in service and the third is shortly to be delivered. These locomotives, one of which can be seen in the accompanying illustration, are of 333 b.h.p., have a four-speed, hydraulically operated gearbox, and weigh 44 tons in working order. We are informed that the first locomotive has been in use daily at Drakelow for up to twelve hours a day forming mixed coal trains, shunting them into tipplers, and back into the empty sidings. On average 175 wagons have to be handled a day, with a gross coal tonnage of about 2600 tons. The acceptance trials on the locomotive included hauling trains of 856 tons in first and second gears against gradients of 1 in 216 and 1 in 247. In third gear at 8 m.p.h. the load hauled on the gradients was 503 tons and 252 tons was hauled at 14·5 m.p.h.

The locomotive has a rigid welded steel frame with a central enclosed cab, the large windows of which give an unobstructed view of all shunting operations. The wheels have cast steel centres and are pressed and keyed on to the axles. Cast steel, single-flange axleboxes are fitted and split thrust collars are fixed to the axles between the boxes to take the side thrust of the wheels. This is a departure from previous practice of taking the thrust on the wheel, and the split collars are fitted with renewable anti-friction metal liners which can be removed and replaced without need for jacking up the locomotive. These thrust collars, situated inside the axleboxes, are in a protected position clear of any dirt or grit which may be picked up by the wheel and fall down on to the wheel bosses.

A further useful point in maintenance is the manufacture of the bronze step of the axlebox with the bore and outside face concentric. When it is required to fit a new step all that is required is to jack the weight of the locomotive off the axle concerned and, after removing the keep, to knock the step round the axle until it can be taken off. A guide groove and path are machined on the housing steps to align them, and a new step is inserted by placing it on the axle and knocking it round into position. A complete axlebox assembly can be removed by jacking up the locomotive and taking off the split collar, the box can then be slid inwards and removed with ease. The connecting-rods are profile burnt from steel plate and fitted with cast steel bosses at their ends to give the required widths for the pins.

The standard Paxman "8RPHL" normally aspirated, vee-form, diesel engine of the locomotive develops 333 b.h.p. at 1250 r.p.m. It is situated at one end of the locomotive and enclosed by removable panels which give adequate access to all parts for maintenance purposes or the removal of complete units. Power is transmitted through a shaft and hydraulically operated cone clutch to the gearbox at the rear end of the locomotive. This four-speed gearbox, of constant mesh design, has a hydraulically operated cone clutch for each gear, the gears being splined to the spinner of the clutch and otherwise free to rotate on the shaft. All four clutches are interchangeable and mounted on the same shaft. An isolating clutch is fitted, and reversal is effected by means of bevel gears and dogs. A gear pump supplies oil at 70 lb per square inch for gear clutch operating purposes.

The makers point out that special measures have been taken in the jackshaft design and location of the gearbox to avoid transmission of the normal driving loads to the gearbox casing. For this purpose the final drive shaft has been made as a sleeve and the jackshaft is carried on bearing housings mounted on the frame side plates, which take the loads. Drive from the sleeve is transmitted through splines to the jackshaft. The gearbox is spigotted into the frame members to assist in isolating the driving loads from the gearbox casing. If it is required to remove the gearbox from the locomotive the jackshaft can either be withdrawn sideways or dropped in the normal way.



333 b.h.p. diesel-mechanical industrial shunting locomotive with four-speed hydraulically-operated gear box

The locomotives supplied for Drakelow are arranged for the following speeds and tractive efforts in both directions of travel :—First gear, 2·5 m.p.h., 24,200 lb tractive effort ; second gear, 4·5 m.p.h., 20,800 lb tractive effort ; third gear, 8 m.p.h., 11,700 lb tractive effort, and fourth gear, 14·5 m.p.h. and 6400 lb tractive effort. It should be pointed out these are not the standard speeds and tractive efforts, as the very low first gear is particularly intended for use when positioning wagons on the tipplers. The standard locomotives have gearboxes giving from 2·7 m.p.h. and 24,640 lb tractive effort to 18·5 m.p.h. and 5060 lb tractive effort. Sets of high-speed ratio gears can be supplied which will give a maximum top speed of 29·5 m.p.h. to meet certain applications. As a matter of interest, it can be mentioned that during a recent visit to Drakelow we were on the first locomotive when it hauled a thirty-nine wagon train of 860 tons without undue effort, starting round a sharp curve and later accelerating to get into third gear on the straight up a small incline.

The straightforward lever controls in the driver's cab are duplicated. The single direction control lever is situated centrally in the cab, whilst those for gear changing, engine speed, braking and sanding are on each side of the cab, easy to hand when the driver is facing the direction of travel. An engine control panel includes gauges for oil pressure, water and lubricating oil temperature, engine speed and starting air pressure. Audible and visual devices are fitted to give warning of engine overspeed, and high water and lubricating oil temperatures. A second panel includes a brake air pressure gauge, a gearbox oil pressure gauge, a speedometer and a mileage recorder.

## Effect of Interrupted Loading on Mechanical Properties of Metals

WE regret that in the second part of the article "Effect of Interrupted Loading on Mechanical Properties of Metals," by Dr. E. W. Evans, in our issue of March 1, we inadvertently reproduced the wrong illustration for Fig. 13 on page 325. The correct illustration is shown herewith, together with the relevant abstract from the text of the article.

Fig. 13 shows typical load/elongation curves for aluminium, and this is the only metal that shows a different behaviour below the maximum load point due to cyclic testing. However, since

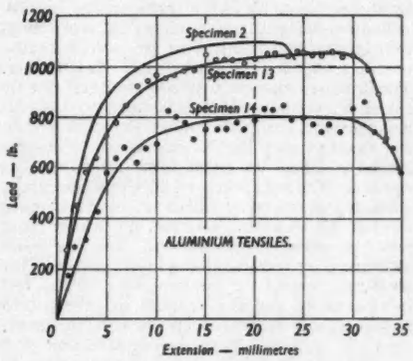



Fig. 13—Specimens two, thirteen and fourteen, showing effect of cyclic loading

the maximum load was about 0·5 ton, it may be that the test now became susceptible to a small but finite delay between the application of load to the specimen and its registration on the gauge of the testing machine.

This section of the work showed that the phenomenon was not confined to steel, and was therefore not due to an ageing process.

## Miniature Motor Car

A LIGHTWEIGHT passenger car has now been introduced by Henry Meadows, Ltd., Fallings Park, Wolverhampton, under the name "Frisky." It follows convention in having a live rear axle and four-speed gearbox, but the engine is a 249 c.c. Villiers air-cooled two-stroke twin and the transmission is by chain. A Siba "Dynastart" is fitted, and can swing the engine in either direction.

The car has a separate body and chassis, the latter being welded up from steel tubes. The body is designed by G. Michelotti in association with Vignale of Turin, and has two doors opening upwards and hinged near the centre line of the roof. The first fifty bodies will be built in steel, but production quantities will be moulded in glass-reinforced plastic. The front seat will hold two adults and a child, and there is room behind it for two more children.

The front suspension is independent on Dubonnet principles, using rubber in torsion as the suspension medium. The rear suspension is by hydraulically damped coil springs. Hydraulic brakes are used, and the lining area is 230 square inches per ton. Periodic lubrication is limited to four grease nipples on the swivel pins. The car has a wheelbase of 5ft, and tracks of 48in front, 34in rear. It weighs approximately 6 cwt and is claimed to cruise at 50 m.p.h. and tour at 75 m.p.g.

# Industrial and Labour Notes

### British Employers' Confederation

The annual general meeting of the British Employers' Confederation was held, in Manchester, last Friday. Viscount Weir was re-elected honorary president, and Sir Colin Anderson was re-elected president. Dr. W. H. Garrett and Lord McCorquodale were re-elected vice-presidents.

In presenting the Confederation's annual report, Sir Colin said that a major responsibility rested on employers and workers and on their respective organisations to mould their own policies in such a way as to make real contributions towards resolving the country's immediate difficulties and to restoring stability. Inflation had been slowed down, but it had not been halted and would not be halted until the same degree of rigour which the restriction of credit had imposed on the private sector of industry was applied to reducing public expenditure.

Sir Colin went on to refer to restrictive practices in industry, recalling that during the past year the Minister of Labour had brought the whole subject under review by his National Joint Advisory Council. That council, he said, wisely decided that progress would only be made by the employers and the trade unions in individual industries carrying out a critical examination of existing practices to see how far those practices impeded the efficient use of manpower. The British Employers' Confederation accordingly asked all employers' organisations to try and arrange with the trade unions for such a joint examination and the Trades Union Congress similarly asked its constituent unions to co-operate. The initial reports, Sir Colin continued, showed that in many industries measures were in train to eliminate practices for which there was no present justification. But in some industries, he remarked, employers appeared to have approached the matter rather tardily and half-heartedly, and in others unions were said to have done so. To deal effectively with the matter, Sir Colin said, would, of course, take time, but it could not be in the general interest of employers to go slow at this juncture. The T.U.C. was endeavouring to persuade reluctant or hostile unions to enter into discussions with their employers' organisations, and he urged all employers' organisations to see, as far as ever they could, that the maximum advantage was secured from the Minister of Labour's initiative.

### Employment and Unemployment

The Ministry of Labour's latest report on the employment situation in Great Britain says that, at the end of January, the number of people engaged in civilian work was 22,971,000 (15,223,000 men and 7,748,000 women). The total was 18,000 less than the number returned a month previously.

In the country's basic industries, there were 3,948,000 people at work in January, the principal change being an addition during the month of 5000 to the number employed in mining and quarrying. This is a figure which to a large extent reflects recent improvements in the strength of coal mining manpower. In the manufacturing industries, the number at work during January was 9,213,000, indicating an overall drop of 13,000 compared with the preceding month. The only increases recorded in this group of industries were in chemicals, metal manufacture and textiles. In "engineering, metal goods and precision instruments" the labour force dropped by 2000 to a total of 2,806,000, compared with 2,830,000 a year earlier. In vehicle manufacturing, there was another fall (of 11,000) in employment, the total for the end of January being 1,197,000, compared with 1,262,000 a year earlier. In other industries and services, the report notes an addition of 3000 to the building and contracting labour force, bringing the number employed there at the end of January to 1,494,000.

A statement on unemployment shows that on February 11 there were 380,060 people registered as out of work, which was 2545 less than on January 14. The February figure represents about 1·8 per cent of the total number of employees. It included 22,685 who were temporarily stopped, and 145,326 who had been unemployed for more than eight weeks. The Ministry says that in the four weeks ended January 26 there were 146,000 operatives working short time in various manufacturing establishments. This was 9000 fewer than at the beginning of January. It is also reported that in the four weeks ended February 6, the employment exchanges filled 153,000 vacancies. The number of vacancies notified to the exchanges but remaining unfilled on February 6 was 239,000 which was 129,000 less than a year earlier.

### Communications in Industry

In the latest number of its *Bulletin*, the British Productivity Council has included the text of an address on "Communications in Industry," which was delivered recently at a meeting in Birmingham by Mr. Alick Dick, managing director of the Standard Motor Company, Ltd. In this address, Mr. Dick suggested that a great deal of the mistrust which existed in industry stemmed from the fact that the information given was not clear, and was expressed in such terms as could not only be misunderstood, but could be consciously, or subconsciously, twisted to suit a particular whim or policy of a department or individual. Poor communication, Mr. Dick said, was one of the prime causes of the present uneasy relationship between management and workpeople; it was failure to express ideas that bedevilled the whole industrial field.

In many cases, Mr. Dick continued, the failure of management to get its aims, viewpoints and problems across to the workpeople had been complete; but less complete had been the failure of the trade unions to control their members at long range. There had been a great change in the position of the trade unions, Mr. Dick remarked, and not the least change was in the position to-day of the shop steward. He said that he was not against the principle of shop stewards. They so obviously had their place in industry, and what was more, men were entitled to appoint representatives to negotiate with management, if they so desired. In many cases, it was an advantage to both parties, and it was possible, Mr. Dick observed, for shop stewards to develop their scope so that they became a filter of information between management and employees. It was necessary to see, he went on, that the viewpoint of management was clearly explained to the employee and that of the employee to the management, without bias, so that employees might have the opportunity of making up their own minds rather than having them made up for them.

### Professional Engineers

On Monday and Tuesday of this week, Mr. J. G. Orr, national secretary of the Engineers' Guild, addressed meetings of the Glasgow and Aberdeen centres of the Guild. The principal theme of his talks at both centres was that a revolution in thought is necessary if Britain is to succeed in training enough professional engineers to enable industry to hold its own in the world in the future.

Mr. Orr recalled the statement, in last year's White Paper on Technical Education, that if the present rate of industrial expansion is to be maintained, the engineering profession would need to be doubled by 1970. Ten years hence, he said, an annual output of 20,000 professionally trained scientists and engineers would be required. That figure, Mr. Orr commented, was the same as that of all university first degrees now being awarded, of which more than 40 per cent were in non-scientific subjects. More teachers, more colleges, and more young people prepared to carry though their education to a higher level were needed. But, Mr. Orr added, a general increase in the size of a profession could not be brought about by planning alone, if the desire to enter that profession was not found in sufficient numbers among young people. He went on to emphasise that conditions must be brought about in which the career prospects for professional engineers, both in remuneration and management were at least as good as those in other professions. The status of engineers, Mr. Orr said, must be restored to a proper level, for, if that could be done, youth would be attracted to the engineering profession in sufficient numbers to justify hope for the future of industry in Britain.

### Capital Investment in Power

In the House of Commons last Monday, the Paymaster-General, Mr. Maudling, was asked if he would make available figures showing relative national investment over the next ten years in all primary energy sources in the light of the latest nuclear power programme. In his reply, Mr. Maudling said that investment in nuclear power stations was expected by the end of 1965 to total rather more than £1000 million, of which a little over £900 million represented the cost, including the initial fuel charge of the stations due for completion by then.

Mr. Maudling added that investment in hydro-electric power in Scotland might, if the present progress was continued, amount to about £120 million. Colliery development by the National Coal Board was estimated at about £850 million over the same period. Indigenous oil resources, Mr. Maudling said, were unlikely to call for much new investment, although substantial sums would have to be found for the development of the world-wide activities of British oil companies in production, refining and distribution.

### Hostels at Technical Colleges

The Minister of Education, Lord Hailsham, has asked local education authorities to consider the provision of hostel accommodation at certain technical colleges. At present, the Ministry of Education has stated, there are very few hostels attached to these colleges, and more must be established. They are needed to give some of the more advanced students the experience of a period of residence at college, and also to provide for students who can attend the college only by living away from home and for whom other accommodation is not available. The initial aim, it is suggested, should be to allow each student at a college of advanced technology to be in residence for at least a year of a full-time course or for one session of a sandwich course.

The Ministry of Education points out that hostels will be needed mainly at colleges of advanced technology or at colleges which will provide courses leading to the Diploma in Technology. Students at other colleges, it is thought, will usually be able to find lodgings within reasonable travelling distance of the college, though there may be exceptional cases in which students can be satisfactorily accommodated only in a hostel provided by the college. Hostels catering for between fifty and 150 students are recommended, each under the supervision of a resident warden. The Ministry says that some employers have given generous help towards the cost of hostels for technical colleges. Though the duty of providing such hostels rests clearly with local education authorities, the Minister of Education has expressed the hope that firms which send substantial numbers of students to particular colleges will consider giving financial help towards the cost of hostels.

### Anglo-German Trade

The Board of Trade states that negotiations between United Kingdom and German delegations have now been concluded in Bonn, establishing quotas for this year to cover trade in each direction in those goods not yet liberalised. Quotas for which increases have been negotiated include United Kingdom exports of certain textiles and some agricultural goods, and German exports of certain scientific and optical goods, textiles, chemicals and other industrial goods and foodstuffs. The negotiations have covered only a small proportion of each country's imports, since a very high percentage has been liberalised.

# Kuibyshev Hydro-Electric Power Station

No. I

*A general description is given of the Kuibyshev hydro-electric scheme, now in operation on the Volga River in the U.S.S.R. The scheme is very large, and will generate about 11,300 million kWh annually when the plant installation, which will have a capacity of 2,100MW, is complete. Our article is based on information obtained from several Russian publications; it concludes with some information about the design and construction of the generating plant at Kuibyshev.*

FROM time to time in these columns, we have published brief descriptions, as information became available, of the post-war water power schemes constructed in Russia. Electrical power in that country is generated principally from thermal-electric power stations, and water power in only a small part of the total. Nevertheless the Russian water power schemes are of special interest, since much of the development has been concentrated at a few sites where the scale of operations is, of necessity, enormous. Several noteworthy sites are being surveyed, or construction is actually under way, on Siberian rivers, which in some cases promise blocks of power of the order of 3,000MW from one site. Development of the Volga River is, however, further advanced, and power is now being generated from new stations constructed on that river.

A stretch of the River Volga near Moscow has, in fact, been utilised for power production since before the war, when the Ivanov, Urglich, and Shcherbakov schemes were built. Following the river down from these developments, further sites were selected at Gorki, where power was first generated at the end of 1955, at Kuibyshev and at Stalingrad, at both of which work is well advanced. There are to be nine power stations altogether in the Volga "cascade," and further projects are contemplated at Cheborksar and Saratov, upstream and downstream respectively of Kuibyshev, and at Astrakhan near the mouth of the river. The scale of these works can be judged from the total installed capacity for the nine stations, namely 8200MW. The Kuibyshev and Stalingrad stations together will account for about half of this total.

At Kuibyshev, which we now propose to describe, the twelfth generating set went into operation at the beginning of this year. Thus the capacity now in operation is 1260MW. Recent reports indicate that the thirteenth set is about due to start generating, and it is planned to complete all twenty by October. The Kuibyshev scheme is the pride of Russian civil engineers, not only on account of its size, but because of various technical refinements. It is stated, for instance, that the speed of its construction is unequalled. It has also introduced into Russian practice the large-scale use of hydraulic emplacement of filling material for the embankments, and the large-scale application of concreting at freezing temperatures. The scheme is similar in general layout to the other projects on the Volga, being essentially a low-head development, on a very large scale. Thus extensive impounding embankments are needed, with spillway, power station and navigation locks laid out at strategic points where concrete construction replaces the earth banks. An overall idea of the scope of the scheme can best be given by the leading hydrological and generating data, which for convenience we have listed in Table I overleaf. The nominal capacity listed for the station —2100MW—corresponds to the normal gross head of 19m

At the Kuibyshev site (which is about 80km from the town of that name) the River Volga changes direction, and flows to the east round the Zhigulev mountains. The right bank is high and steep, but there is a flood plain on the left bank, with a river terrace behind it.

The power station abuts on to the high ground on the right bank side, and is built out across part of the natural river bed of the Volga, but head-race and tail-race canals have been constructed on the right bank side to serve the power station. Following the impounding works out from the right bank, there is an "island" pier on the river side of the power station, separating the head and tail-race canals from an earth dam which is carried across the remainder of the river bed and continues over the Telyachii island. On the left bank side of this island is the flood plain which is closed by the concrete spillway dam. The port works and lock entrance are grouped close to the left bank end of the spillway dam, from which they are separated by a length of earth dam. The earth dam completes the impounding works by stretching from the end of the spillway dam to the high ground on the left bank side.

Extensive port facilities are provided at the upstream level. Passage downstream is effected by passing through the port to either of a pair of locks, which give access to a large intermediate basin, which, in its turn, is served by a second pair of locks at its downstream end. A canal leads back to the Volga from these lower locks, and the river bed has been widened and deepened to complete the new navigational system. In the photographs reproduced with this article we show various stages in the constructional works for the scheme.

## The Power Station

The site of the power station was selected at the right bank side of the scheme principally

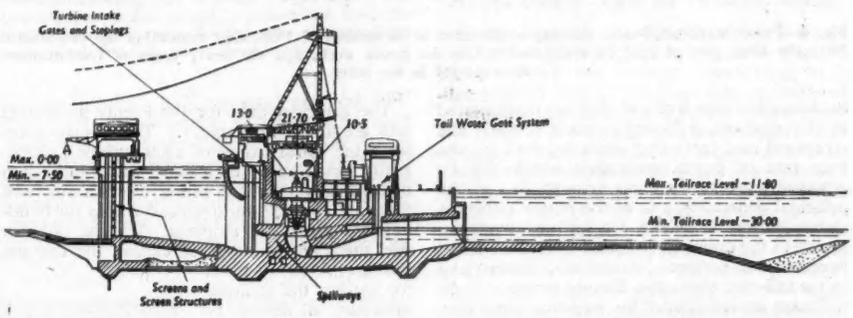



**Fig. 1—The layout of the power station, which incorporates spillway passages and has a separate screen structure on the upstream side, is shown in this sectional illustration**

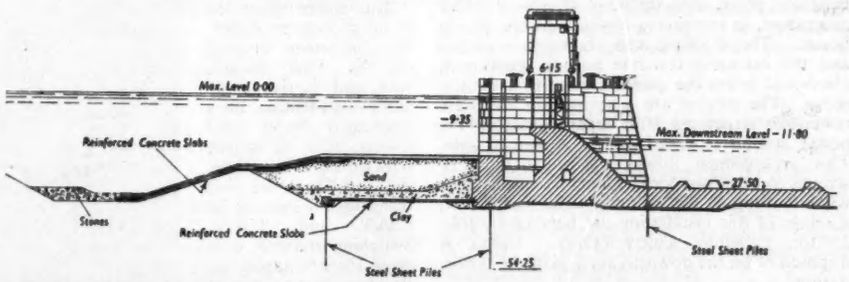



**Fig. 2—The spillway dam is of concrete construction, as shown here. Discharge is controlled by thirty-eight sluice gates, each 20m by 10m in size, giving a capacity of 40,000 cumecs**

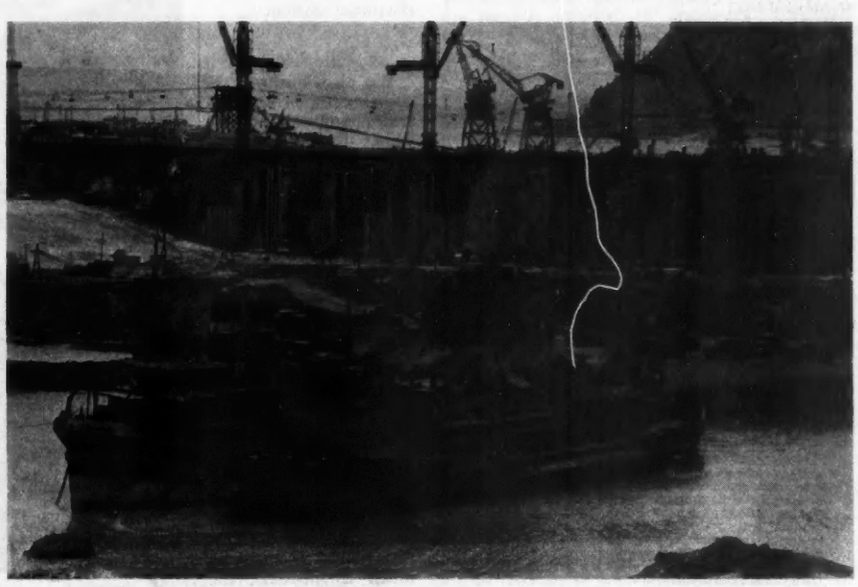


**Fig. 3—Progress of the power station in October 1955. The upstream side of the power station is shown, with a bucket dredger excavating the power station cofferdam**

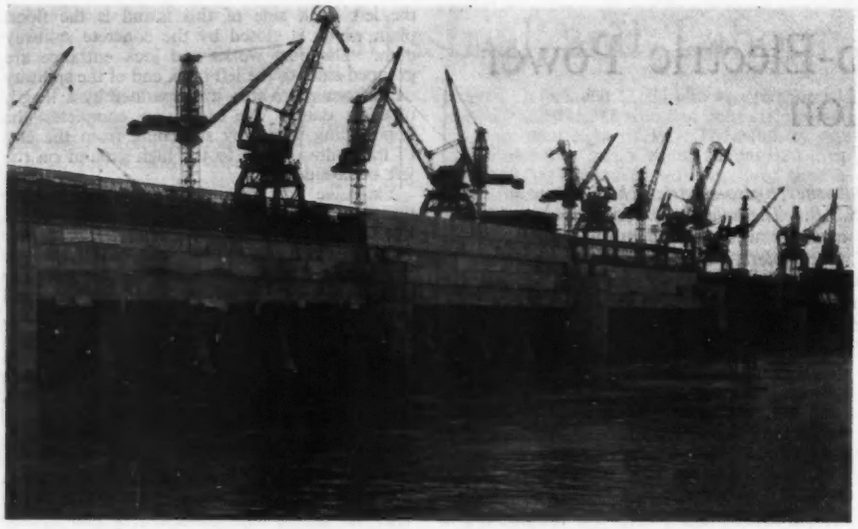


**Fig. 4—Power station tail-race, showing construction in the summer of 1956, after removal of the cofferdams. Note the large precast concrete slabs used to face the in-situ work, and the heavy cages of reinforcement incorporated in the latter**

because a formation of stiff clay was encountered in this position, sufficiently strong to carry the structural and hydraulic loads imposed by the high rate of power generation which will be achieved. A cross section through one of the principal generating sets of the power station is shown herewith. There are spillway passages, shown in the drawing by dotted lines, positioned beneath the turbine intakes and discharging to the tail-race above the draught tubes. These spillways are introduced for economy, since they allow reduction of the length of the spillway dam by a third; but apparently they also have a beneficial effect, from the point of view of power generation, in improving flow conditions during floods. The drawing also shows the cut-offs and the extensive concrete aprons, built both above and below the power station to minimise scour. The screens are supported in elaborate tower-like structures built separately from the power station structure on the upstream side. This arrangement allows individual bays of screens to be closed for cleaning or maintenance without stopping the turbines. The screens and stoplogs of this installation are handled by four 250-ton travelling gantry cranes. Debris is disposed of on the downstream side of the power station.

TABLE I—*Kuibyshev Hydro-Electric Scheme*

| | |
|---|---|
| **Hydrological data :** | |
| Mean annual flow, cumecs | 7,700 |
| Estimated maximum flood, cumecs | 67,000 |
| Storage capacity of reservoir, cubic metres × $10^9$ | 52,300 |
| Surface area of reservoir, square kilometres | 5,600 |
| Maximum width of reservoir, kilometres | 40 |
| Length of reservoir : | |
| Along Volga River, kilometres | 600 |
| Along Kama River, kilometres | 300 |
| **Power generated :** | |
| Power generated in year of average rainfall, kWh × $10^6$ | 11,300 |
| Total installed capacity, MW | 2,100 |
| Number of generating sets | 20 |
| Nominal capacity of each set, MW | 105 |
| **Power station :** | |
| Normal gross head, metres | 19 |
| Maximum gross head, metres | 30 |
| Turbine and alternator details : | |
| Designation of set | Vertical Kaplan |
| Turbine runner diameter, metres | 9·3 |
| Stator diameter, metres | 20·0 |
| Power station e.o.t. cranes : | |
| Number | 2 |
| Capacity of each, tons | 450 |
| Total length of power station, metres | 600 |
| Width of power station, metres | 100 |
| Height from foundation level, metres | 80 |
| Cubic content, cubic metres | 3 × $10^6$ |
| **Impounding structures :** | |
| Total length of impounding structures (i.e. including power station, &c.), metres | 5,500 |
| Total length of concrete spillway dam, metres | 1,000 |
| Maximum height of spillway dam, metres | 30 |
| Total length of earth dams, metres | 2,800 |
| Maximum height of earth dams : | |
| Section in river bed, metres | 50 |
| Section on flood plain, metres | 28 |
| **Navigational works :** Comprising a pair of locks upstream, and a pair downstream of an intermediate basin, and downstream, an approach canal and river widening. There is a port at the upstream end of this system. | |
| Waterway of intermediate basin : | |
| Length, metres | 3,800 |
| Width, metres | 600 |
| Length of downstream approach canal, metres | 6,000 |
| Length of downstream widening and deepening of Volga, metres | 6,000 |

The principal data for the twenty generating sets are listed in Table I. Two intake gates serve the spiral casing of each turbine; apparently they are equipped with individual hydraulically operated lifting mechanisms, and there are two 400-ton overhead cranes for handling the gates and stoplogs. On the tail-race side there are stoplogs for closing the draught tubes, and eighty gates for closing the spillway openings, all served by two 250-ton travelling gantry cranes.

The power generated is stepped up to 400kV by transformers situated on the power station roof, and carried away along high-tension lines suspended from steel towers, 60m in height, built on top of the power station. There are also transmission systems at 220kV and 110kV. Switching stations, covering these voltages, are situated at two points on the banks, and are served by cables from the power station.

### The Spillway Dam

We also illustrate in cross section, the concrete spillway dam, which has been built across the river's left bank flood plain. The dam is built on a formation of sand of considerable thickness, and, like the power station, is characterised by elaborate concrete aprons for scour protection; in this case, there are three steel-sheet-piled cut-offs, the two principal ones driven to a depth of about 21m. The construction of the upstream apron is clearly shown in the drawing. Downstream, there are flow-retarding blocks and sills arranged to dissipate, as much as possible, the energy of flood discharges, and rip-rap protection is also made use of. There is a considerable amount of reinforced concrete slabs and other work in these scour-protecting structures.

The capacity of the spillway dam is quoted as 40,000 cumecs at normal reservoir level. The crest is controlled by thirty-eight vertical-lift sluice gates, each 20m by 10m in size. Three travelling cranes, each of 250 tons capacity, handle the gates.

### Earth Dams and Other Works

Hydraulic emplacement of fine-grained sands, pumped from the left-bank flood plain, was the method used to construct the embankment dams of the scheme. In the river bed, the dam of this kind is founded on sand and gravel, and in the flood plain, on sandy clay and loam, and fine-grained sand. Reinforced concrete slabs and pitched stonework protect the banks from erosion, and stone toes have also been built.

The port at the upstream end of the canal is laid out, in basic shape, by earth dams. Mechanised facilities for trans-shipment of cargoes to rail or road are provided. In the dredged channel at the intermediate level, between the two stages of locks, there is a ship repair yard.

Many subsidiary works are necessitated by a project of this size, for rehousing, establishing communication, and so on. The impounding works, for instance, carry the main Moscow-Kuibyshev road and the main railway line from Kinel to Sizran. Several new communities have been established, grouped around the main works, and much attention has been paid to the architectural design and planning of them. The reservoir extends into forty-seven administrative regions, including a large number of towns and villages, and considerable rehousing and rebuilding is called for. In some cases protective structures are being built to limit the encroachment

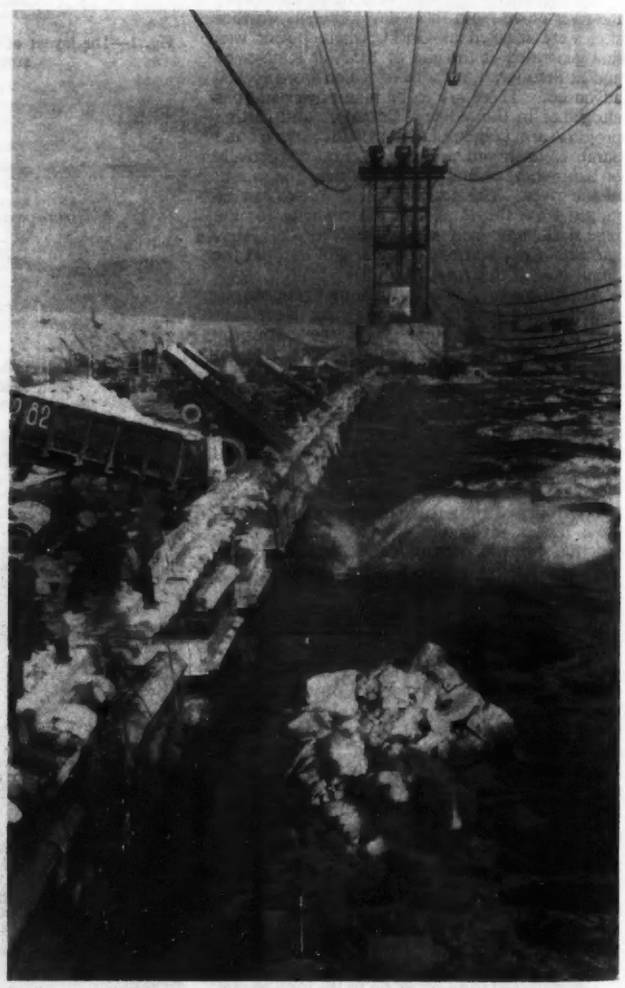


**Fig. 5—Closure of the Volga was effected in October, 1955. Rocks and 10-ton concrete pyramids were dumped into the river channel from the pontoon bridge shown here. The channel was 350m wide, and 1600 10-ton pyramids and 6000 cubic metres of rock were dumped**

of the reservoir. Anti-malarial measures have also been taken. Navigation will be fundamentally changed by the scheme for about 900km of the Volga and Kama rivers, and new ports are being built, the largest at Kazan and Ulyanovsk.

We have sufficient information to give only a very brief idea of the methods of construction adopted at the Kuibyshev site. Work was started in 1950, and in the early stages cofferdams were built to enclose sections of the power station, the spillway dam and the locks and port. Earth dams were used to form these cofferdams; at the left bank they totalled 8km in length, and were up to 22m in height; at the right bank they extended for 1·5km, and were up to 25m in height.

Numerous communities were set up to house those engaged on the project, and plant, workshops, quarries and so on, were set up on a scale commensurate with the gigantic task ahead. It is stated that the degree of mechanisation was high; examples given are for concrete-making and for the hydraulic emplacement of sand-fill. Power consumption per head during construction is quoted as 4·5kW (maximum demand 75MW). Some of the principal quantities of structural materials in the completed scheme are as follows: embankment fill, 150 million cubic metres; reinforcing steel, 44,000 tonnes; concrete, 7,500,000 cubic metres; steel piling, 40,000 tonnes; plant and equipment of various kinds erected, 170,000 tonnes; steel structures, 81,100 tonnes. Concreting reached its peak in the summer of 1955, and in August of that year a rate of concreting of 19,000 cubic metres per day is claimed to have been reached, a rate unequalled by far, it is stated, on any other project in the world. In September, 1955, the lower locks were brought into use, and in November the river was sealed by closing the dam; power was first delivered from the scheme on December 29, 1955. Closure of the dam is illustrated; river flow was diverted through the spillway sluices to the power station, while the closure operation was in progress.

The reservoir is being filled in three stages. The first stage, with sufficient impounding to operate the turbines, was reached, as we have just noted, at the end of 1955. In the spring of 1956 an increase of 9m was achieved in the reservoir level (i.e. to give 24,000 million cubic metres of water in the reservoir), and it is expected that this year the spring floods will fill the reservoir to its final level. A further 300,000 cubic metres of concrete was scheduled to be placed during the twelve months' interval between these two stages, so as to complete the impounding works and bring the upper locks into operation. Power is to be transmitted to Moscow at an annual rate of about 6000 million kWh, the balance being consumed in the Volga, Trans-Volga and central regions, and in the Northern Caspian and Urals.

*(To be continued)*

## Portable Gas Detector

The accompanying illustration shows the "Model 19/31" gas detector, made by Drägerwerk Heinr. and Bernh. Dräger, Moislinger Allee 53/55, Lübeck, German Federal Republic. The instrument is designed to give the approximate quantitative analysis of air which contains small amounts of certain impurities. Usually these impurities are toxic substances, the concentration of which in workrooms must be kept below the so-called "MAC" values (maximum allowable concentrations), which are those concentrations at which particular substances are known from experience to be harmless over very long periods of daily eight-hourly exposures. "MAC" figures are very small and vary according to the nature of the substance present, between a fraction of one part per million and a few hundred parts per million.

The Dräger gas detector comprises a bellows pump to which is fitted a gas testing tube. By squeezing the bellows, the air is expelled. Internal spring pressure then expands the bellows again, when, owing to the arrangement of valves, air is drawn in through the sampling tube. This process is repeated the required number of times. In this way the volume of air and the

**Gas detector being used to test a flanged joint. Gas concentration in the sample is determined from the length of discoloration in the test tube, and sometimes from the colour change itself**

manner in which it is aspirated are kept constant, since the volume is merely the total stroke volume of the bellows, while the rate is governed by the spring force and the resistance to flow. The latter is varied according to the sensitivity of the reaction, by appropriately narrowing the end of the indicator tube. Table I shows the range of gases or vapours for which indicator tubes are supplied.

Development work is continuing with the object of adding further substances to the list,

TABLE I

| Poisonous gases or vapours | Range of indication (mg/litre) | Range of indication (p.p.m.) |
|---|---|---|
| Alcohol | 0·25–20 | 200–15,000 |
| Ammonia | 0·05–10 | 72–14,400 |
| Arsine | 0·0001–0·015 | 0·5–5 |
| Benzene | 0·05–2 | 15–600 |
| Benzene-Toluene | 0·1–3 | 30–900 |
| Benzene-Toluene | 1–10 | 300–3,000 |
| Carbon dioxide | (0·5–ca. 5%) | 5,000–50,000 |
| Carbon dioxide | 1–ca 20% | 10,000–200,000 |
| Carbon disulphide | 0·04–1 | 13–320 |
| Carbon disulphide | 1–10 | 300–3,000 |
| Carbon monoxide | (0·001–0·3%) | 10–3,000 |
| Carbon monoxide | (0·5–10%) | 5,000–100,000 |
| Chlorine | 0·002–0·2 | 0·7–70 |
| Hydrocarbons (petrol) | 2–50 | 540–13,500 |
| Hydrogen sulphide | 0·01–1 | 7–700 |
| Mercury vapour | 0·0001–0·02 | — |
| Nitrous gases | 0·01–0·2 | 5–100 |
| Phosgene | 0·002–0·3 | 0·5–75 |
| Hydrogen cyanide | 0·001–0·2 | 0·9–180 |
| Sulphur dioxide | 0·02–3 | 8–1,200 |
| Trichloroethylene and other halogen hydrocarbons | 0·1–10 | 18–1,800 |
| Water vapour | 1–200 | — |

and of making the existing tests still more sensitive, thereby reducing the number of pump strokes required for each test. Thus, the mercury test previously required 100 strokes, while a recently developed tube allows this number to be reduced to twenty.

As a rule, the reactivity of indicators is adjusted so that the range covers the toxic concentration of the gas involved. The detector may also be used to determine non-injurious admixtures such as water vapour; in other cases undesirable components may be analysed, e.g. benzene in solvents. One of the principal difficulties in arriving at correct test results is that of obtaining a representative sample. For instance, while in a garage the average concentration over a period of carbon monoxide may be harmless, the question arises whether or not the larger temporary concentrations from running engines are dangerous. In such cases, it is often possible to come to a conclusion by examining, with the detector, the breath of people who have been exposed to the gas. The "Model 19/31" detector is handled in this country by Normalair, Ltd., 27-31, Minshull Street, Manchester 1.

### German Nuclear Power Plants

By 1965 the Federal Republic hopes to have three atomic power plants, each generating 100MW. The Federal Ministry for Atomic Questions is at present negotiating for the purchase of land. It is hoped that atomic test stations on a smaller scale will be ready for service by 1962.

Disposal of atomic waste, it is stated, will not be an insoluble problem for the chemical industry by the time the first German nuclear reactors come into service. The Bundestag is being asked almost to double its budget from DM.44,300,000 in the past year to DM.84,100,000 for the coming fiscal year.

Britain's atomic industry has promised the Federal State of North-Rhine-Westphalia to deliver two nuclear reactors which are to be set up near Düren and will serve the institutes of technology at Cologne, Bonn, and Aachen as research centres. One will be of the "Merlin" type, a swimming pool reactor worth DM.2,000,000. The other is of the "Dido" type and will require a total outlay of DM.30,000,000. Only one-fifth of this reactor is to be built in England while the remaining parts will be manufactured under licence in the Federal Republic.

### Internal Coolant Feed for Grinding Wheels

A very high degree of surface finish is stated to be obtainable with grinding wheels the pores of which contain the coolant. According to a recent E.P.A. digest,* coolant can be supplied to the wheel by means of a simple device which can easily be produced in the workshop. It consists of a container in the shape of a truncated cone with open top and flat closed bottom. A central hole in the bottom serves to bolt the container against the wheel on the grinder spindle, while a circle of small holes near the container rim allows coolant fed to the container to flow to the wheel under the action of centrifugal force. A layer of filter paper between wheel and container ensures an even distribution, while a rubber ring near the container's edge prevents throw-off. Coolants must be clean and of low viscosity. During standstill, the container must be empty to prevent an unbalance caused by the coolant seeping into the lower part of the wheel.

### Fédération Européenne de la Manutention

Section I of the "Fédération Européenne de la Manutention," which comprises the manufacturers of heavy lifting apparatus, held its seventh meeting in Brussels on February 8, 1957. The object of the meeting was to continue the studies necessary for the establishment of a European standard for lifting equipment.

After examining the report which had been presented by the technical sub-committee, which had met in Paris on January 9 and 10, 1957, the section decided to continue, in various F.E.M. member countries, tests which had already been commenced, and which sought to establish standardised dynamic coefficients. A technical secretariat is to be set up in Paris which will co-ordinate all the tests and the preparation of the draft rules. The next meeting of the section will be held in Vienna in October, 1957, during the fifth congress of the "Fédération Européenne de la Manutention."

### Computer Microscope for Gauging Tree Growth

An instrument for automatically determining the age and relative growth of trees has been developed in Sweden by assistant professors B. Eklund and O. Langlet. The machine, a combination of electric computer and microscope, not only counts the concentric rings in the wood but also measures their width from year to year. Cores taken out of the tree are tested for the influence on growth of various grades of thinning and intermediate cutting. To obtain this information had previously been a very time-consuming procedure. Now, about 2000 rings per hour can be counted. The instrument is already being used by the Institute of Forest Research and the Committee for the Assessment of the National Forests.

* E.P.A.—D. 1028, obtainable T.I.D.U., D.S.I.R., Cunard Building, 15, Regent Street, London, S.W.1 (free on application).

# Sodium Graphite Reactor Electric Power Plants

BY OUR AMERICAN EDITOR

*The Sodium Graphite Reactor Experiment now approaching completion in the Santa Susana Mountains near Canoga Park, California, is representative of the current technical co-operation between the U.S. Atomic Energy Commission and American industrial concerns interested in producing electrical power from nuclear energy. The construction of the reactor and the power plant is being handled by the Atomics International Division of North American Aviation, Incorporated, and the 20MW thermal output of the pile will be used by the Southern California Edison Company to produce 7·5MW of electricity for commercial sale. Based on the design of this pilot plant, Atomics International has now developed a 75MW commercial atomic power station design, which is described.*

THE Sodium Graphite Reactor (SGR) System has been developed to produce economical power from nuclear energy. Its use for power generation is based on present technical feasibility and a belief that future design and fuel improvements will result in even better performance. It is hoped that the engineering development of the sodium graphite reactor and its heat extraction system may eventually permit the production of steam temperatures limited only by turbine performance. At present the sodium graphite reactor system provides a heat transfer temperature of 925 deg. Fah., with a projected temperature of 1200 deg. Fah. The high operating temperatures and correspondingly high thermal efficiencies permit good steam conditions in the power conversion equipment. The use of conventional engineering materials and standard components is a factor which contributes to the reduction of capital and operating charges in the power reactor systems.

In 1954, North American Aviation, Incorporated, entered into a joint programme with the U.S. Atomic Energy Commission to build an experimental sodium graphite reactor and thus extend the known area of information on the sodium-cooled, graphite-moderated reactor concept. This reactor, known as the Sodium Reactor Experiment (SRE), has been designed and installed as a separate facility at the company's field laboratory in the Santa Susana Mountains, near Canoga Park, California. The photographs reproduced herewith show several stages of construction of this reactor pilot plant. The Sodium Reactor Experiment is a 20 thermal MW pilot reactor, incorporating the principal design aspects of a full-scale sodium graphite reactor. Included in the pilot installation are the heat transfer systems, the fuel handling system and the instrumentation and control systems. It was originally planned merely to dissipate the reactor heat through air-blast heat exchangers. However, the Southern California Edison Company has recently been authorised to use this heat to produce electrical power. A complete steam generating plant has been installed to produce 7·5 electrical MW, which the Southern California Edison Company will feed into its regular transmission lines and sell commercially. The ultimate aim of the Sodium Reactor Experiment is to provide the technological data and operational experience required to attain improved reactor performance, plant investment economies and simpler maintenance procedures.

## Reactor Design

The design of the sodium graphite reactor is sufficiently flexible to match a wide range of steam conditions and power requirements. A representative power plant is described here to illustrate the basic design and performance characteristics. This plant follows the general specifications of the plant of 75MW net electrical output, which has been proposed by Atomics International to the Consumers Public Power District of Nebraska. The plant is designed for a gross electrical output of 80,000kW approximately, which includes an estimated 4000kW for station auxiliary power. The reactor thermal power is 240MW.

The arrangement of the principal components of the plant is shown in Fig. 1. The reactor core is contained in a large diameter steel tank situated below ground and cooled by liquid sodium. The primary sodium coolant flows from the reactor in separate loops to three intermediate sodium-to-sodium heat exchangers which are contained in individually shielded vaults situated below ground level. The individual shielding permits maintenance on the components of one loop without the complete shut-down of the plant. The secondary, non-radioactive sodium, from each intermediate heat exchanger is pumped to the steam generators, from which steam is piped to the turbo-generator.

The active reactor core, (shown in Fig. 2), consisting of fuel and moderator elements, is a cylinder approximately 12ft in diameter by 10ft high, enclosed in a 2ft thick graphite reflector. The core contains 192 fuel elements spaced 9·5in apart in a triangular lattice. An individual fuel element consists of a cluster of nineteen rods secured to a common hanger assembly. Each rod is made up of a column of ten uranium fuel slugs contained in a sealed stainless-steel jacket.

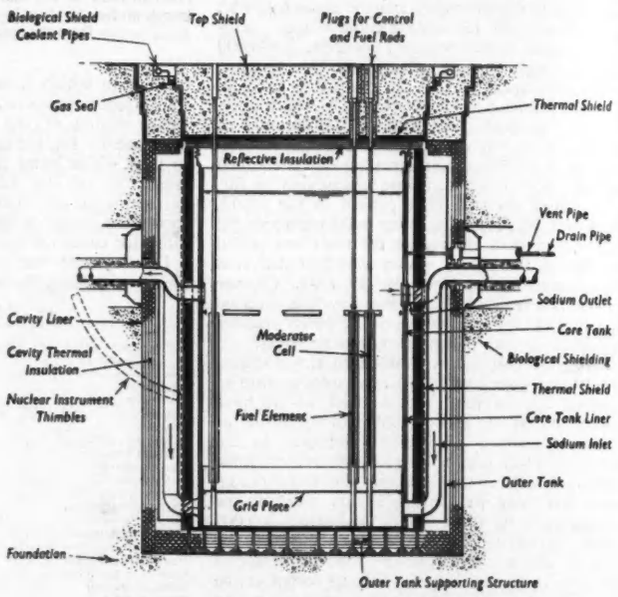



Fig. 2—Arrangement of sodium graphite reactor core

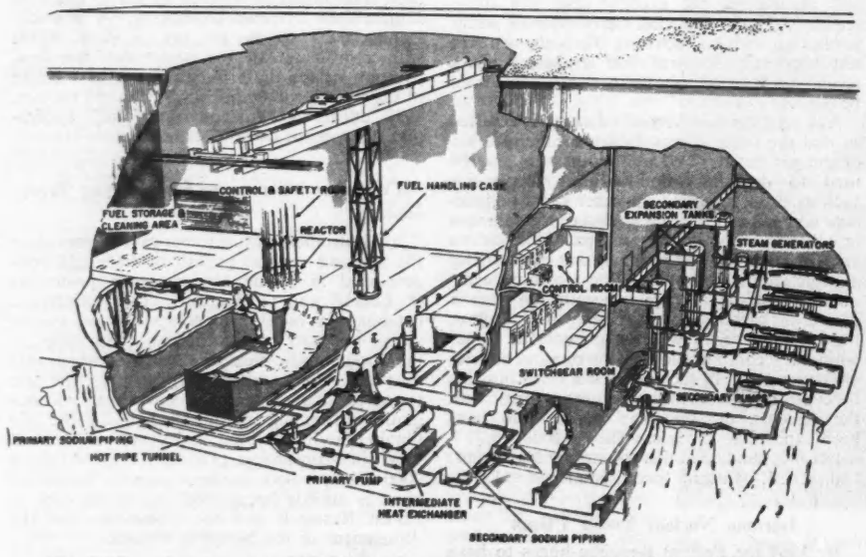
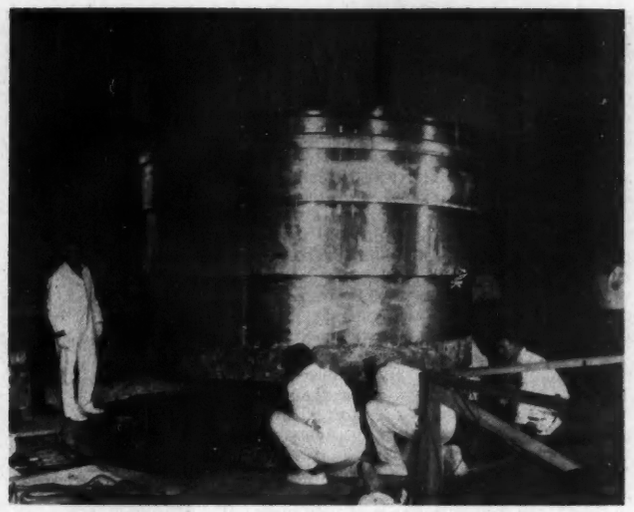



Fig. 1—General arrangement of 75MW atomic power station utilising the sodium graphite reactor

The moderator elements are graphite blocks encased in sealed zirconium cans. An axial tube which extends through the length of the moderator element contains either a fuel element or a control rod assembly and is the channel for the coolant flow through the core. There are 211 moderator elements in the core. In 192 of them, fuel elements are suspended ; in eighteen of them control and safety rods are inserted ; and one houses the neutron source which provides an initial neutron flux for start-up. Graphite was chosen as the moderator because it is mechanically easy to handle compared with hydrogenous moderators and is considerably cheaper than beryllium, which might also be used. The principal disadvantage of graphite as a moderator is its porosity ; it acts like a sponge when in contact with liquid sodium. The moderator elements are contained in the sealed zirconium cans to separate the graphite from the sodium. Zirconium was selected as the can material because it does not readily absorb neutrons and because it is relatively compatible with both sodium and graphite in the operating temperature range. The graphite reflector elements which surround the active core are very similar to the moderator elements except that they do not contain fuel-coolant tubes.

The uranium fuel is enriched in U-235 to 2·3 per cent, compared to natural uranium, which



**Figs. 3 and 4—(Left) Control room of Sodium Reactor Experiment with indicating and recording instruments and operator's console. (Right) 75-ton loading face shield of Sodium Reactor Experiment being aligned with fuel element and control rod channels in the reactor core during installation**

contains approximately 0·7 per cent U-235 and 99·3 per cent U-238. The reactor operates at a specific power of 473kW per kilogramme of U-235 with an inventory of 518 kg of U-235. The total weight of uranium in the reactor is approximately 22,500 kg. The average neutron flux is estimated at $2{\cdot}0\times10^{13}$ neutrons per square centimetre-second. The conversion ratio (atoms of plutonium formed/atoms of U-235 destroyed) is 0·72. Some of the reactor operating characteristics are listed in the following table :

*Sodium Graphite Reactor Characteristics*

| | |
|---|---|
| Reactor operation : | |
| Nominal rated output, thermal | 240MW |
| Average thermal flux in fuel, neutrons per second-square centimetre | $2{\cdot}0\times10^{13}$ |
| Initial atomic percentage of U-235 in fuel | 2·3 |
| Fuel inventory, kilogrammes | 22,500 |
| Expected conversion ratio | 0·71 |
| Sodium coolant system : | |
| Primary inlet temperature | 500 deg. Fah. |
| Primary bulk outlet temperature | 925 deg. Fah. |
| Flow rate, per hour | $6{\cdot}42\times10^{6}$ lb |
| Steam production data : | |
| Pressure at turbine throttle | 800 lb per square inch gauge |
| Temperature at turbine throttle | 825 deg. Fah |
| Steam production, per hour | 710,000 lb |
| Electrical power data : | |
| Gross generation | 80·8MW |
| Net generation | 75MW |

The entire core assembly is contained in a stainless steel core tank. The tank is approximately 17ft in diameter by 28ft 6in deep. Surrounding the core tank are thermal shielding, insulation, a mild steel outer tank and concrete radiation shielding. The top shield, above the core, is composed of several feet of heavy concrete and can be removed should major repairs to the core be required. Near the bottom of the core tank is a grid plate which locates the moderator and reflector elements and separates the lower plenum from the region around and between the elements. Each element is supported by a hollow pedestal which extends through the grid plate and opens into the lower plenum. The pedestals provide passages for the heat transfer sodium from the lower plenum to the moderator element coolant channels. Sodium is supplied to the region between the elements through eighteen of the reflector element pedestals.

The use of a liquid metal such as sodium as a heat transfer fluid has many advantages. While solid at room temperature, it melts at 208 deg. Fah. and is therefore easy to keep liquid in a power plant system. Sodium boils at 1620 deg. Fah. and thus permits adequately high coolant temperatures with the system at atmospheric pressure. Because liquid metals, and sodium in particular, have extremely high thermal conductivity, they are excellent heat transfer media. The fluid dynamics of liquid sodium is similar to that of water. A further advantage of sodium is the general absence of chemical corrosion in metal systems. As a result, a wide variety of steels and other alloys may be utilised as construction materials. Sodium, however, is not without certain disadvantages. It reacts chemically with oxygen and water and must therefore be isolated from these. Furthermore, when exposed to neutrons as in a reactor, it becomes a strong radioactive gamma-ray emitter with a half-life of about fifteen hours, and thus creates a serious problem in nuclear power plant applications. For these reasons the steam boiler has been separated from the primary sodium by a non-radioactive secondary sodium system which carries the heat from the primary system to the boiler.

Sodium enters the core cavity at an elevation slightly above the top of the fuel elements and passes through downcomers outside of the core tank. It enters the lower plenum below the fuel elements and flows upward through and around the fuel elements, leaving the core cavity at about the same level at which it entered. The outlet pipe has an upward, offset bend just outside of the core tank so that the high point in the system is external to the core tank. This means that in case of a leak in the piping outside of the core, the sodium level in the core tank would not fall below the outlet nozzles and, therefore, sodium flow could continue in the remaining loops. As the primary sodium flows through the core it removes heat from the fuel elements, the moderator and reflector elements, and the thermal shield. This useful heat represents more than 98 per cent of the total energy produced in the reactor. The heat generated in the shielding and heat which escapes through the insulation is removed by a separate low-temperature cooling system. The low-temperature coolant can be an organic liquid, such as "Tetralin," which is chemically non-reactive with sodium.

Three parallel primary loops connect the core to the intermediate heat exchangers. The primary piping runs through the hot pipe tunnel to the three individual cells containing the components of each loop. The hot pipe tunnel and the cells are individually shielded to permit shut-down and maintenance of one loop while the other loops continue to operate. The heat transfer system is shown schematically in Fig. 7. Primary sodium enters the core at 500 deg. Fah. and leaves at 925 deg. Fah. A 30 deg. Fah. temperature difference exists across the intermediate heat exchanger so that secondary sodium enters the steam generator at 895 deg. Fah. The total steam produced from the three heat transfer loops is 730,000 lb per hour at 850 lb per square inch gauge.

A sodium service system is provided for melt-

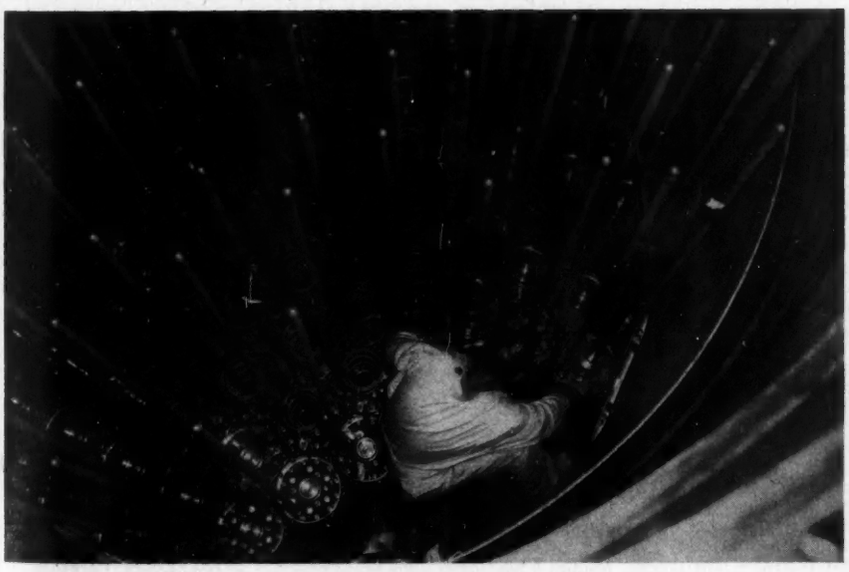


**Fig. 5—Core of Sodium Reactor Experiment with 119 graphite moderator cans, fuel element guiding coils and gas pressure control pipes**

ing, filtering and transferring sodium to the heat transfer system. An inert gas, either helium or nitrogen, is used wherever an inert atmosphere is necessary to prevent the oxidation of the graphite or the sodium. The reactor power level is regulated by eighteen control and safety rods. Each rod consists of a number of neutron absorbing boron-nickel rings mounted on a stainless steel tube. The rods operate within steel thimbles which extend into the core in ordinary coolant channels.

Of the eighteen rods, eight are for safety purposes and are completely withdrawn from the core during operation. The reactor is provided with interlocks and safety circuits covering every conceivable serious malfunction. In the event of a potentially dangerous incident the safety rods are automatically released by one of the safety circuits and fall by gravity into the core. The eight safety rods control more than enough reactivity to shut down the reactor. The steam generation rate is controlled by adjusting the sodium flow in the reactor heat transfer system. As the flow varies, the sodium temperature is held constant by repositioning the control rods to change the reactor power level. By means of the reactor control system the rods can be positioned either automatically or manually.

### Thorium Fuel Reactor

Two reactor core designs are being developed for this plant—the one just described for use with uranium fuel and a second one for use with thorium-base fuel. Thorium is a fertile material which, under neutron bombardment, can be transformed into U-233, a fissionable uranium isotope. U-233 is not found in natural uranium ; it is a synthetic element formed only by transmutation from thorium. The initial fuel charge of a thorium-base fuel reactor includes both U-235 and thorium. As the U-235 fissions, the thorium absorbs neutrons and is converted to U-233, which then becomes the reactor fuel. If the conversion ratio (atoms of U-233 formed/atoms of U-235 destroyed) is less than 1, the reactor must be refuelled periodically with both thorium and U-235. However, if the conversion ratio can be made greater than 1, the reactor becomes a breeder in which enough U-233 is formed to continue a self-sustaining nuclear reaction and only thorium need be added in subsequent refuellings.

The thorium sodium graphite reactor is almost identical to the uranium-fuelled reactor. They differ only in fuel element design and in certain of the core dimensions. The thorium reactor fuel element is a seven-rod cluster. Each rod consists of ten thorium–U-235 alloy slugs contained in a sealed stainless steel jacket. There are 185 fuel elements in the reactor spaced 8in apart in a triangular lattice. The atomic fraction of U-235 in thorium is 3·70 per cent, giving an average thermal neutron flux in the fuel of $3{\cdot}1\times10^{13}$ neutrons per square centimetre-second. The conversion ratio is expected to improve as U-235 is replaced by U-233—starting at about 0·675 and ultimately levelling off at about 0·81. The thermal rating of the thorium reactor is 250MW. At this rating the maximum zirconium-sodium temperature is limited to 950 deg. Fah. and the sodium inlet to the reactor is 500 deg. Fah. The calculated central thorium temperature is 1600 deg. Fah. This high fuel temperature is one of the major advantages of the thorium system. Uranium metal undergoes a change in crystalline structure at about 1220 deg. Fah., which at the present time limits its performance to temperatures below this point. The thorium-uranium alloy, on the other hand, can withstand temperatures as high as 2000 deg. Fah. and thus the thorium-base fuel element will probably be operated at higher temperatures and produce greater power per fuel element.

### Operation of Power Station

The operation and maintenance of the 75MW reactor power station will require approximately the same number and calibre of personnel as are required for the same functions in a conventional steam power station. New requirements, it is stated, are associated with the reactor and sodium systems of the nuclear plant and also with the health physics functions.

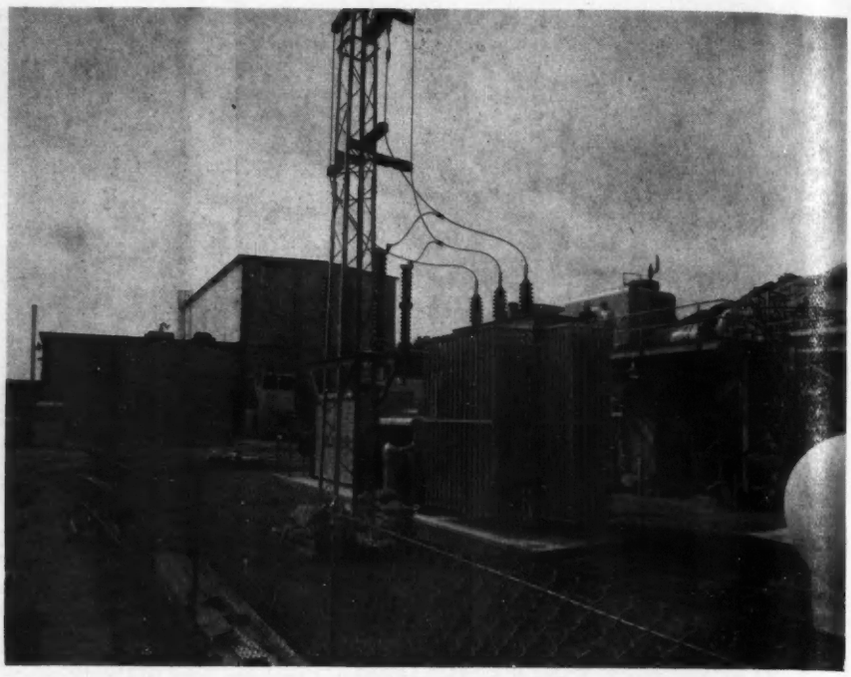


**Fig. 6—Sodium Reactor Experiment site with reactor building in background and outdoor installation of 7·5MW turbo-generator, heat exchanger, condenser, transformer and switchgear in foreground**

The reactor and fuel areas are situated below ground, using earth and concrete for shielding purposes. The primary heat transfer system and the steam generating unit on present designs are also situated below ground level, enclosed in shielded cubicles of reinforced concrete. The turbo-generator and accessory equipment do not require shielding and can be situated within the building or on the exterior as design requires. Units such as feed-water tanks and drain tanks may also be situated adjacent to the building. The height of the building must be sufficient to handle the crane needed for fuel handling. The bridge structure is designed to support the crane and the weight of components being removed from the core.

### Steam Cycles

The selection of an initial steam cycle for a nuclear power plant involves a compromise between two competing factors. These are (1) maximum heat removal from the reactor, and (2) maximum efficiency in converting heat energy to electrical energy, i.e. thermal efficiency. The heat removal rate in this system is proportional to the rate of flow of the coolant fluid and to the temperature difference across the core. These two factors must be balanced to produce optimum conditions. To keep the pumping power low, the temperature difference must be fairly large. The present state of metallurgical development sets an upper limit on the core temperature and the lower limit is more or less defined by the fact that a high thermal efficiency requires a high average sodium temperature. These various competing factors have been evaluated for the sodium graphite reactor plant, and the core and sodium system designs reflect the best combinations from the standpoint of both performance and economics.

The non-reheat regenerative steam cycle appears to be the optimum choice for such an installation. In conventional power stations fuel economy can be considerably increased by the use of five or more extraction feed-water heaters, which raise the temperature of the feed-water to about 400 deg. Fah. In a nuclear power plant, however, a high feed-water temperature has a detrimental effect. It either lowers the maximum possible steam pressure with a consequent loss in cycle efficiency, or it decreases the reactor power output. Studies which have been made have shown that the best regenerative feed-water temperature for nuclear power plants is in the range from 250 deg. to 300 deg. Fah.

In the present reactor design the maximum primary sodium and zirconium temperature has been limited to 950 deg. Fah., which brings about a mixed mean sodium outlet temperature of about 925 deg. Fah. A 30 deg. Fah. temperature difference in the primary-to-secondary sodium heat exchangers results in a secondary sodium temperature of 895 deg. Fah., which, for a 70 deg. Fah. approach in the hot end of the superheater, permits a steam temperature of 825 deg. Fah. A three-stage feed-water-heating arrangement was selected to obtain a final feed-water temperature of 300 deg. Fah. Preliminary heat-balance calculations show a turbine cycle heat rate of 10,050 B.Th.U. per kilowatt-hour for a gross electrical output of 80,800kW.

The steam system includes a by-pass line to divert steam around the turbine directly to the condenser. The line leads through a pressure-reducing and desuperheating station. It is used during start-up and to dissipate after-glow heat following shut-down. It is also used to absorb reactor power in case the generator trips off the line. Both the primary and the secondary sodium loops are constant-temperature, variable-flow systems. The sodium flow is programmed according to the turbine load to produce the required steam flow. The sodium temperature is held constant during changes in flow by reactor power level adjustment. The sodium temperature and, therefore, the steam temperature, can be held relatively constant during any normal load variation. For the final control of steam temperature a spray attemperator is provided at the superheater outlet. The steam pressure is held approximately constant throughout the load range.

The control sensitivity of the sodium graphite reactor plant is expected to be comparatively high. From the control standpoint there are no apparent restrictions to using the plant for load or frequency regulating applications in a power grid. It is expected that operating experience with the sodium reactor experiment and future metallurgical developments will raise the present reactor temperature limit. To estimate the gains that may result from the expected improvements in reactor performance, two successively higher steam conitions have been examined. The attainment of the standard steam conditions of 850 lb per square inch gauge at 900 deg. Fah. requires only a relatively modest extension of the basic design. For example, it is possible to increase the superheater surface and decrease the temperature approach from 70 deg. to 45 deg. Fah. It would then be necessary to

raise the primary sodium outlet temperature to 975 deg. Fah., an increase of only 50 deg. Fah. over the present outlet temperature. In the same manner, the attainment of the standard steam condition of 1250 lb per square inch gauge at 950 deg. Fah. requires a mean sodium outlet temperature of 1025 deg. Fah., an increase of 100 deg. Fah. over the outlet temperature of the present basic design.

### Power Costs

The total cost of power consists of (1) capital charges on the investment in the station and the equipment, and (2) operating charges for fuel fabrication and processing, operating personnel, and plant maintenance. The capital charges for construction in the United States of a 75MW power station have been estimated to be approximately 165 dollars per installed kilowatt of electrical capacity for the reactor portion ; 15 dollars per installed kilowatt for the sodium steam generator, and 120 dollars per installed kilowatt for the electrical portion of

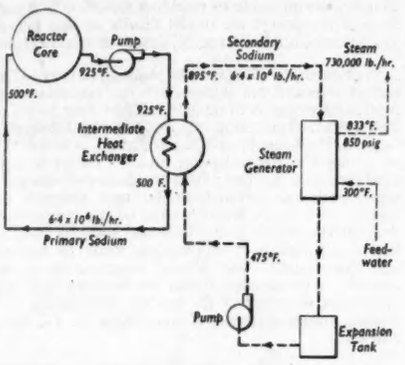



**Fig. 7—Flow diagram of sodium graphite reactor power plant**

the plant. These three items total 300 dollars per installed kilowatt for this particular nuclear plant. Using 15 per cent annual charges against the capital investment and assuming an 80 per cent load factor, the contribution of capital charges to the power costs is 6·5 mills per kilowatt-hour (1 mill=0·001 dollar). The total fuel costs for the 75MW plant have been estimated to be 2·0 to 3·2 mills per kilowatt-hour and the fixed operating and maintenance charges of the nuclear plant contribute 2·0 mills per kilowatt-hour. The total combined cost of power from this station is estimated at 10·5 to 11·7 mills per kilowatt-hour. As a comparison, the average total cost for a similar size of conventional hydro-carbon-fired plant in the United States is 6 to 8 mills per kilowatt-hour.

The power costs given in connection with the nuclear power plant are based on (1) conservative design limitations, and (2) cost data extrapolated from experience obtained in the construction of the sodium reactor experiment and the design of the 75MW plant. Thus, these costs are based on what can be expected from these "early demonstration" programmes, which have involved laboratory-scale fabrication, solving research and development problems along the way. It is hoped that reductions in power costs from sodium graphite reactor plants will be obtained from improvements in three broad areas : (1) design and manufacturing simplification, (2) improved utilisation of nuclear fuels, and (3) increased thermal efficiency. Many of the present capital costs will undoubtedly be reduced as industrial experience in the nuclear power plant field is developed. Although the extent of such cost reduction is uncertain, it is not unreasonable to expect that the capital costs of nuclear plants may eventually be about the same as present conventional plant capital costs.

Certain improvements in nuclear performance can also be expected. In a thorium-uranium fuel reactor, for instance, the use of a blanket of thorium can reduce the productive loss of neutrons. There is reason to believe that a slightly larger reactor core with an improved core design and utilising an effective blanket arrangement will yield a conversion ratio of about unity. With such a design, after initial fuel loading, the only feed material to the reactor would be thorium metal. The use of thorium-base fuel will permit the production of considerably more power from each fuel element. With higher core temperatures and an increased sodium velocity, the heat output of the present design would be increased by more than 50 per cent. The present development programme is also expected to raise the 950 deg. Fah. limitation on the maximum sodium temperature. Advances in this direction will permit a further increase in thermal power and improved steam conditions. The thorium-base fuel element is capable of taking advantage of higher sodium temperatures, since very high centre temperatures in the metal can be sustained. With the eventual availability of a higher sodium temperature, the use of a reheat-regenerative steam cycle or a super-critical pressure cycle will become desirable.

## Magnetic Alloy of High Permeability and Low Hysteresis Loss

Substantial improvements in magnetic amplifiers, switching and memory devices, pulse transformers and power transformers are now believed to be possible as a result of a new magnetic alloy which has been developed at the Bell Telephone Laboratories, of Murray Hill, New Jersey. The material will permit reductions in the size of magnetic components without any sacrifice in performance, and will facilitate the design of new components having greatly improved performance characteristics. Called "Supermendur," the alloy has a number of exceptional properties, including higher permeability and lower hysteresis losses at higher flux densities than any material heretofore available. The composition of "Supermendur" nominally is 49 per cent iron, 49 per cent cobalt and 2 per cent vanadium, and is similar to "2V-Permendur," a magnetic alloy developed at the Bell Telephone Laboratories many years ago. However, H. L. B. Gould and D. H. Wenny have now improved the characteristics of the alloy considerably. The hysteresis losses have been reduced by a factor of 10. The maximum permeability is now 66,000 at 20,000 gauss ; the remanence is 21,500 gauss ; the coercive force is 0·26 oersted, and the saturation is 24,000 gauss. The core losses are under 6W per pound at 400 c/s at a flux density of 100,000 lines per square inch. The hysteresis loop is rectangular with a flux swing of 45,500 gauss from minus remanence to plus saturation.

These outstanding properties have been achieved by using commercial materials of the highest purity, melting in a controlled atmosphere furnace, and subjecting the resulting alloy to a prescribed schedule of rolling and heat-treatment in a magnetic field. The material is so malleable that it can be cold rolled from 0·090in to 0·0003in without intermediate anneals and without losing its ductility. To obtain such an extremely thin finishing gauge, the tape is finish-rolled on a reversing Rohn cluster rolling mill having work rolls of very small diameter. Power transformer cores of 0·004in or 0·002in "Supermendur" tape can provide an output more than 30 per cent greater than comparable cores of grain-oriented silicon steel, which had been considered to be the best previously available material. The advantages on an ampere-turn excitation basis are even greater, resulting in a reduction in core size and weight of at least 30 per cent for the same output. The flux density can exceed 140,000 lines per square inch without excessive losses.

The characteristics of the new material make it ideally suited for power transformers, pulse transformers, and magnetic amplifiers. The precipitous sides of the hysteresis loop indicate that the gain of a magnetic amplifier can be increased as much as 80 per cent over that obtainable with grain-oriented silicon steel. Other possible applications include telephone receiver diaphragms and switching and memory devices. The material may be especially useful where "miniaturisation" is desired, or where high-temperature operation is contemplated. At present, the Western Electric Company, the manufacturing part of the Bell Telephone organisation, does not plan to produce "Supermendur" for commercial consumption. However, a number of companies have expressed an interest in the material and it probably will be manufactured in the United States under Western Electric licence in the near future.

## Aluminium Production in the Ohio River Valley

The new aluminium production works of the Kaiser Aluminum and Chemical Corporation at Ravenswood, West Virginia, recently went into partial operation. Already in production are certain cold rolling facilities, together with annealing furnaces, slitters, shears and other auxiliary equipment installed for turning out light-gauge sheet. The first foil mills have also started rolling. At the Ravenswood Works, Kaiser Aluminum is constructing two factories, each one being a large plant in its own right. They are laid out on a 2500-acre Ohio River site to provide maximum efficiency in an integrated operation in which molten primary aluminium produced from alumina in the reduction plant will be cast directly into ingots for the adjacent rolling mill. When completed, the rolling mill will have an annual capacity of 169,150 short tons of fabricated products. The reduction plant initially will have four potlines with an annual capacity of 125,000 tons of primary aluminium, and an enlargement to a capacity of 220,000 tons is contemplated as the aluminium market warrants it. The construction of these two facilities has set the pace in the American aluminium industry's move to the Ohio Valley. It will be the first operation in the U.S. aluminium industry based on the fact that coal is the most economic source of electrical energy for the production of aluminium when situated close to major markets and a direct transport route for raw materials. The recognition of this fact led Kaiser Aluminum to the Ohio River Valley site at Ravenswood where low-cost power based on coal is readily available, where 70 per cent of the American aluminium consumption is within a 500-mile radius and where the company is able to move materials from the mine to the fabricating works in a direct line over a short all-water route.

The cold-rolling facilities now in operation at Ravenswood are for the present using reroll stock obtained from the corporation's works at Trentwood, Washington. In the building bays surrounding those containing the equipment in operation, work is being completed in the installation of the remainder of the facilities. It is expected that the ingot casting facilities and the hot rolling mill will begin operation by the latter part of the summer and that the first metal will be poured from the first potline of the reduction plant at about the same time. Other potlines are expected to begin production at intervals of two months. The electric power required for the rolling mill and for the production of the primary aluminium will be obtained from the Ohio Power Company, a subsidiary of the American Gas and Electric Company, under a forty-year contract.

The hot rolling mill line has been designed to take 16in thick ingots weighing up to 10,000 lb. The hot line equipment includes 168in and 110in reversing mills and a 100in five-stand continuous mill. There will also be a 144in plate mill. The rolling mill is to have what is claimed to be the world's largest plate stretcher, capable of stretching sections of plate up to 6in thick and up to 12ft wide. This machine is being installed to supply the aircraft industry with stress-relieved plate from which to machine integrally stiffened wing panels and other structures.

The situation of these works at Ravenswood in Jackson County, West Virginia, will turn a region that has depended on a rural economy into a modern industrial centre. From a population of about 15,000 in the last census it is forecast that the county will more than double its population in the next few years. Upon its completion in 1958, the Ravenswood Works will provide employment for some 4000 workers.

# Personal and Business

## Appointments

BROOK MOTORS, Ltd., has announced that Mr. Geoffrey Stott has been appointed sales engineer at its Glasgow office.

THE GENERAL ELECTRIC COMPANY, Ltd., has announced that the Rt. Hon. A. R. W. Low has been appointed a director.

MR. B. BUTCHER, organising superintendent and labour manager of Samuel Fox and Co., Ltd., has been appointed a director.

MR. K. B. BLAKE, A.M.I.E.E., has joined the staff of The Electric Construction Company, Ltd. He will be dealing with special projects.

THE A.E.I. LAMP AND LIGHTING COMPANY, Ltd., has announced the appointment of Mr. E. G. Long as superintendent of the Bristol area.

MR. M. F. DOWDING, engineering sales manager of Davy and United Engineering Company, Ltd., has been appointed a director of Davy and United Roll Foundry, Ltd., Middlesbrough.

THE BRITISH ROPEWAY ENGINEERING COMPANY, Ltd., states that Mr. Max Clayton has been appointed a full-time working director and Mr. William Gilmore has been appointed a special director.

MR. J. L. THOMAS has rejoined The Cape Asbestos Company, Ltd., as Scottish area branch manager at Glasgow. He replaces Mr. D. A. Lambert, who relinquished the appointment at the end of last year.

THE NATIONAL COAL BOARD states that Mr. R. H. E. Thomas has been appointed chairman of the opencast executive in succession to Dr. W. Reid, who has become chairman of the Durham Divisional Board. Mr. H. W. Hembry has been appointed deputy chairman of the opencast executive.

RANSOMES, SIMS AND JEFFERIES, Ltd., has announced the appointment of Mr. D. H. Stocker as publicity manager. He succeeds Mr. R. B. Reeve, who has retired after forty-four years' service with the firm. Mr. R. J. Garnham has relinquished his position as public relations officer to become manager, lawn mower sales. He succeeds Mr. E. J. Bradley, who will retire at the end of April.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., announces the following appointments: Mr. H. Smith has been appointed joint managing director of the general chemicals division and has been succeeded as joint managing director of the dyestuffs division by Dr. C. R. Mavin; Mr. R. S. Wright has been appointed production director to the dyestuffs division, and Mr. J. Grange Moore, works and personnel director of the Wilton Council.

## Business Announcements

MR. ALEX. R. HUTCHIESON, M.I.Mech.E., has retired from the keepership of the technological department of the Royal Scottish Museum.

RANSOME AND MARLES BEARING COMPANY, Ltd., states that it has opened a new area office at 378-380, Argyle Street, Glasgow, C.2 (telephone, Glasgow Central 3948).

THE DUNLOP RUBBER COMPANY, Ltd., states that Mr. Harry Webb, manager of the machine tool department at Fort Dunlop, has retired after forty-two years' service with the company.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., has announced that it has concluded an agreement with the National Research Corporation of Massachusetts, U.S.A., for the manufacture at its Watford works of vacuum melting, heat-treatment and analysing equipment of N.R.C. design.

SIR EDWIN PLOWDEN, chairman of the United Kingdom Atomic Energy Authority, is visiting the Union of South Africa as guest of the South African Government. The purpose of Sir Edwin's visit is to meet those concerned in South Africa with atomic energy development, and in particular with the mining of uranium.

SAMUEL DENISON AND SON, Ltd., states that it has opened area sales offices as follows: North West: King's House, 42, King Street West, Manchester, 3 (telephone, Blackfriars 1986); Mr. H. Hunt has been appointed area sales manager. North East: West Bar Chambers, 38a, Boar Lane, Leeds, 1 (telephone, Leeds 2-8433); Mr. S. A. Morris has been appointed area sales manager.

FOLLAND AIRCRAFT, Ltd., reports that it was announced in the Finnish Parliament last Thursday that the Government had decided to purchase twenty Gnat Mk. I aircraft from Valmet OY, who will construct these machines, under licence from Folland Aircraft, Ltd., at the Valmet Works at Tampere, Finland. It is expected that to assist initial production orders for tooling and for the manufacture of several sets of parts and components, will be placed with Folland Aircraft, Ltd., for production at Hamble. This announcement follows the Finnish Government's order for twelve Gnat Mk. I aircraft which was placed with Folland Aircraft, Ltd., last October.

## Contracts

BRISTOL AIRCRAFT, Ltd., has received a contract for fifty "171" Mk. 14 "Sycamore" helicopters, worth several million pounds, from the Federal German Government. The machines will be used by the German Army, Navy and Air Force for ambulance, air/sea rescue, and transport duties.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has obtained an order valued at more than £1,500,000 for two 120MW (C.M.E.R.) turbo-alternator sets for the new Padiham "B" power station of the Central Electricity Authority (North West Merseyside and North Wales Division). The turbines are to be designed for steam conditions of 1500 lb per square inch gauge at 1000 deg. Fah. with reheat to 1000 deg. Fah. The alternators will be hydrogen cooled. These turbo-alternator sets will be made in the new B.T.H. Turbine Factory at Larne, Northern Ireland, and are to be ready for commercial load during the 1961 and 1962 commissioning programmes, respectively.

THE CENTRAL ELECTRICITY AUTHORITY has placed contracts during the past month for power stations, transforming stations and transmission lines, totalling £17,067,800. The principal contracts include: South Denes power station, Yarmouth, two 550,000 lb per hour boilers, Mitchell Engineering, Ltd.; Rugeley power station, two 120MW reheat boilers, Babcock and Wilcox, Ltd.; Aberthaw power station, 132kV, 3500MVA switchgear, Ferguson Pailin, Ltd.; Skelton Grange B power station, Leeds, four 120MW reheat boilers, Mitchell Engineering, Ltd.; Capenhurst substation, 132kV, 3500MVA switchgear, English Electric Company, Ltd.; Checkerhouse substation, two 60MVA, 132/33kV transformers, Bruce Peebles and Co., Ltd.; Fleet substation, 275kV, 7500MVA switchgear, Metropolitan-Vickers Electrical Company, Ltd.; High Marnham–Keadby–Monk Fryston, 275kV overhead line, British Insulated Callender's Construction Company, Ltd.

## Miscellanea

CORRECTION.—In our article on "Fan Compressors" (February 8, page 231) we stated that low-pressure cylinders of these machines are made of light alloy, whereas it is the low-pressure pistons which are made of light alloy. The high-pressure pistons are made of cast iron.

LONDON PASSENGER TRANSPORT.—The first prototype "Routemaster" has now returned to trials on routes 260 and 2 after having modifications carried out in Chiswick Works. The radiator, formerly below and behind the driver, is now exposed in front of the engine, the length having been increased 4in over 27ft. Power-assisted steering has also been incorporated, together with a fresh warm air heating system for both decks.

PRODUCER GAS CONFERENCE.—The British Coal Utilisation Research Association announces that it is organising a "Conference on Practical Aspects of the Generation and Utilisation of Producer Gas" which will be held at the Majestic Hotel, Harrogate, on April 16 and 17. The all-in conference fee is £6 6s., and applications should be made to the Superintendent, Gas Producer Department, B.C.U.R.A., Randalls Road, Leatherhead, Surrey.

PHYSICAL SOCIETY EXHIBITION.—The forty-first Physical Society Exhibition will be held in the Old and New Halls of the Royal Horticultural Society, Westminster, from Monday, March 25, to Thursday, March 28. At 6.15 p.m. on the first three days there will be lectures on "The International Geophysical Year," by Sir Harold Spencer Jones, F.R.S., on "The Supply and Distribution of Liquid Helium," by Dr. E. Mendoza, and on "Recent Developments in Acoustics," by Professor E. G. Richardson, respectively.

VACATION TRAINING COURSES.—The Shell Petroleum Company, Ltd., states the six-week vacation training courses for university students at Shell oil refineries, chemical plants, research centres and laboratories, will again be available this year. The courses, which are open to students of chemistry, physics, chemical and mechanical engineering, metallurgy and biology, will be from July 1 to August 9 and from August 12 to September 20. There will be special courses for a limited number of arts students.

GERMAN STUDY TOUR.—In announcing its third tour of German industry, the Industrial Welfare Society points out the value to the participants of organised group visits, in which men from firms in different trades take part. In the last five years, the Society has organised such tours in Germany, Holland, Sweden and Switzerland. The present visit will take place during the period April 23-May 5, in a party which will be limited to forty persons. Full details may be obtained from Mr. John Stamps, Industrial Welfare Society, 48, Bryanston Square, London, W.1.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—On February 26, Mr. H. Volpich and Mr. I. C. Bridge presented a paper entitled "Paddle Wheels, Part IIa, Further Model Experiments," and "Part III, Ship/Model Correlation," before the Institution of Engineers and Shipbuilders in Scotland. Part IIa of the paper gives the results of some further experiments with the large model eight-float model wheel using wood and steel floats and testing the effect of shape. In Part III the relationship between ship and model wheel performance is considered and an attempt made to establish factors which may be used to convert the model results to ship figures and hence be applied to wheel design or trial analysis.

SYMPOSIUM ON SHELL ROOF CONSTRUCTION.—The second international symposium on concrete shell roof construction is to be held in Oslo from July 1 to July 3 next. It is being organised by the Norwegian Engineering Society, and the technical business will be grouped in the following topics: recent notable shell structure designs; new trends in shell designs; prestressed and precast shells, and research on shells; and finally an evaluation of the symposium. Provisional details of the technical sessions indicate that a distinguished international body of authors will contribute. The official language is to be English. Further details may be obtained from the organising secretary of the second symposium, Der Norske Ingenioforening, Kronprinsens gt. 17, Oslo, Norway.

ADVANCED AERONAUTICAL EDUCATION.—The Royal Aeronautical Society has arranged a week-end conference on Advanced Aeronautical Education, to take place on Saturday and Sunday, March 23 and 24, at the College of Aeronautics, Cranfield. At this meeting the Chair will be taken by Professor A. R. Collar (chairman of the Society's Education Committee). An introductory address will be given by the president, Mr. E. T. Jones. The main emphasis of this meeting will be on discussion, but to serve as a basis for the discussion three papers will be read by Professor A. J. Murphy, (principal of the College of Aeronautics), Mr. R. L. Lickley (technical director and chief engineer, Fairey Aviation Company, Ltd.), and Professor A. V. Stephens (Professor of Aeronautics, Queen's University, Belfast). In these papers attempts will be made to define the requirements of the aircraft industry and to discuss these in relation to the provisions made by educational establishments.

ROAD DEVELOPMENT IN NIGERIA.—The Government of the Federation of Nigeria has been given a grant of £1,800,000 from Colonial Development and Welfare funds for the improvement and extension of the federal trunk road system of Nigeria. The trunk roads consist of over a sixth of the country's 32,000 miles of roads. This is the second grant made towards the Nigerian five-year road programme; the earlier grant of £1,500,000 was announced in December 1955; the total cost of the programme is estimated at £13,633,000. It is stated that the development of Nigeria's road system is essential to meet the needs of the country's rapidly expanding economy and the increasing use of road transport, there being an urgent need both to widen and tar many of the existing roads. The grant just approved will be used to meet 50 per cent of the cost of surfacing and improving a further 451 miles of roads, bridgeworks, the provision of additional ferries at unbridged river crossings and the reconstruction of certain existing roads. Assistance will also be given towards the costs of construction of some new roads, included among which is a new approach road to Apapa Wharf at Lagos, to be known as Western Avenue, which forms part of a comprehensive plant to improve road access to the port. The British Government has already made grants of £3,450,000 to the Northern Region Government, £971,400 to the Eastern Region Government, and £659,000 to the Southern Cameroons Government for the development of roads for which those Governments are responsible, i.e. class B trunk roads which supplement the main trunk system, and other local roads.

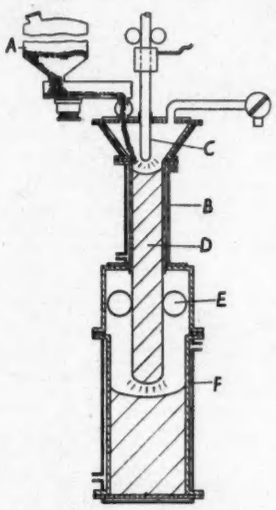
# British Patent Specifications

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.*

## METALLURGY

**767,721.** December 18, 1953.—THE MELTING OF HIGH MELTING POINT METALS OR ALLOYS, Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1. (*Inventor: Jack Preston.*)

The invention relates to an improved arc-melting electrode and its use in the arc-melting of high melting point reactive metals and alloys, such as titanium, zirconium, molybdenum, thorium, hafnium, tantalum, chromium and their alloys. Referring to the drawing, titanium sponge or pelleted material is fed from a hopper *A* into a cooled crucible *B* where it is heated by an arc discharge from an electrode *C*. The raw material remains in the heated zone beneath the arc for a sufficient length of time for the individual particles to commence to melt and to adhere to one another. The coherent mass *D* is drawn down by driven rolls *E*, the rate of withdrawal and the rate of feed of raw material being so adjusted that the material in the heated zone does not become completely molten but is a mixture of solid and liquid metal.

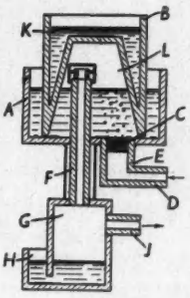



No. 767,721

Cooling is rapid beyond the heated zone and the molten metal solidifies, thus forming a coherent mass. The lower extremity of the coherent mass *D* projects into a second cooled crucible *F* of greater diameter than crucible *B* where it is completely melted as a consumable electrode with the addition of raw material to form a wholly melted ingot. The whole operation is carried out in an inert atmosphere. When the mass *D* is used as a consumable electrode, the rolls *E* and the crucible *B* must be electrically insulated from the crucible *F* which will be of the same polarity as the electrode *C*. Alternatively, the solidified electrode *D* can be removed when of a convenient length and melted in a separate furnace and in a second embodiment of the invention, the consumable electrode may be manufactured in a furnace designed solely for that purpose and then transferred to the main furnace. In a third embodiment of the invention the same main structure of the furnace is used, but crucibles of different diameter are employed successively for the electrode manufacture and the subsequent ingot melting.—*February* 6, 1957.

**768,913.** April 20, 1955.—THE EXTRACTION OF ALUMINIUM, The Societe d'Electro-Chimie, d'Electro-Metallurgie et des Acieries Electriques d'Ugine, 10, rue du General Foy, Paris, France.

The invention relates to a device for the commercial extraction of aluminium from its alloys or from material in which it is contained. The device is intended for carrying into effect the known method which consists in the reaction on these alloys or materials, at a suitable temperature, of an aluminium halogenide so as to form a volatile sub-halogenide which is then cooled in a separate chamber in such a way as to cause the separation in the pure state of the aluminium absorbed and the liberation of the initial halogen salt, which is recovered and recycled. In the form illustrated in the drawing, the device comprises a tank *A* surmounted by a bell *B* having double walls. The tank is provided with an orifice closed by means of a porous plug *C*, which may also be a plate pierced with a number of holes or a multitubular diffuser, communicating with a conduit *D* which leads the halogenide to a chamber *E*. A further orifice is formed in the tank through which is passed an extraction tube *F* made of material which is not attacked by molten aluminium, such as calcined alumina. The tube *F* leads into a chamber *G*, the lower part of which constitutes a tank *H* and the upper part is provided with a conduit *J* for evacuating the halogen compound. The portion of the tube *F* between the tank *A* and the chamber *G* is covered with heat-insulating material. The whole upper assembly is maintained at a temperature between 1100 deg. and 1400 deg. Cent. The chamber *G* and the tank *H* are maintained at a temperature below 1000 deg. Cent., but above the melting point of aluminium the tube *D* and the conduit *J* being brought up to a temperature which is at least equal to the temperature at which the vapour tension of the halogen compound is equal to atmospheric pressure. A liquid metal *K* is provided between the walls of the bell *B*. Thus, the liquid starting material employed determines the temperature of the lower portion of the reaction chamber *L*, whilst the temperature of the liquid metal *K* determines that of the upper portion, a suitable choice of this temperature enabling the temperatures to be uniformly distributed, thus avoiding premature condensation in the reaction chamber *L*. In addition, the extraction tube *F* passes through the liquid primary material and is thus maintained at that temperature. The advantage of the arrangement described is that it enables the operation to be carried out in a semi-continuous manner. It is actually possible to extract the primary material, whether molten or not, from time to time from the annular space between the bell and the tank and to draw off from it the residues resulting from the action of the halogen compound on the primary material. In the same way, it is possible to take off from the tank *H* the quantities of pure aluminium so formed, within the limits necessary to maintain a suitable level of this liquid metal in the chamber *G*. Modified arrangements are also described in the specification.—*February* 20, 1957.

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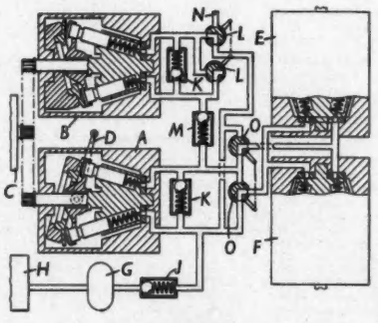
## ROAD TRANSPORT

**768,573.** July 17, 1954.—HYDRAULIC POWER TRANSMISSION SYSTEMS FOR ROAD VEHICLES, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventor: Owen Napier Lawrence.*)

The invention has for its object to provide in a simple and convenient form a hydraulic power transmission system for a road vehicle, and particularly a tractor. Referring to the drawing, the system there shown includes two swashplate pumps *A* and *B*, arranged in parallel and driven by the engine *C* either separately or jointly. The pump *A* is of the variable output type, and the pump *B* is of the constant output type. The inclination of the swashplate in the pump *A* is variable by a lever *D* for varying the pump output. For actuating the wheels of the vehicle there are provided two swashplate hydraulic motors *E* and *F*,

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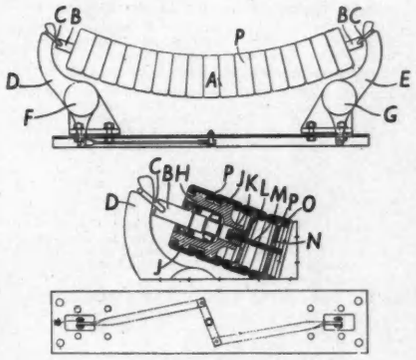
connected to the pumps by pipes in the manner shown to form a closed circulatory system for the liquid. For replenishing the liquid to compensate leakage or other losses, a pump *G* is provided which is supplied from a tank *H* and is connected to the system through a non-return valve *J*. To prevent the development of an excessive liquid pressure in the system, the inlet and outlet of each pump are interconnected by spring-loaded valves *K*. For controlling the system there are provided in suitable positions, as shown, two interconnected valves *L*, which are jointly movable through 90 deg., and a spring-loaded valve *M*. For effecting reversal of the direction of rotation of the motors, two interconnected valves *O* are provided, also jointly movable through 90 deg. The arrangement is such that motion of the vehicle from rest to a given speed is effected by the variable output pump *A*. In this condition the valves *L* occupy the position in which the pump *B* is isolated from the system and is connected to a drain or tank through the pipe *N*, the valve *M* being held closed by its spring. When the desired speed is attained, further increase of speed is given by moving the valves back to the position shown, thereby bringing the pump *B* into action. In this condition the pump *B* supplements the action of the pump *A* by liquid supplied by it to the system through the valve *M*. The maximum speed is obtained when the pump *A*, acting jointly with the pump *B*, gives its maximum output. Reversal of direction of the motors is effected as already mentioned by actuation of the valves *O*. The invention is not restricted to the use of the particular forms of pumps and motors illustrated, as any other convenient pumps and motors may be employed, provided that the output of one of the pumps is variable. Also, instead of the valves *O* for reversing the action of the motors, in the system illustrated, this action may be obtained by isolating the pump *B* and effecting reversal of the action of the pump *A* by moving its swashplate to the appropriate position.—*February* 20, 1957.

## CONVEYORS AND TRANSPORTERS

**768,356.** November 26, 1953.—IDLER ROLLERS FOR BELT CONVEYORS, Richard Sutcliffe, Ltd., Universal Works, Horbury, Wakefield, Leonard Sinclair Barnish, 11, South Parade, Wakefield, Leslie Baines, 306, Denby Dale Road, Wakefield, Ivor Johnson, 5, South Street, Ossett, Yorkshire, and Eric Bottomley, 29, Towngate, Mapplewell, Near Barnsley.

The invention relates to hammock idler rollers which allow the conveyor belt to take up a trough shape when loaded sufficiently. The hammock idler *A* terminates in short shafts *B* to which are attached links *C* by means of which the idler is suspended between two supporting arms *D* and *E* which are

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pivotally mounted at *F* and *G* respectively. The detailed construction of the idler may be seen from the centre view. The shaft *B* is mounted in a bearing of which the housing is indicated at *H*. The housing is provided with two projecting circumferential ribs *J* and the right-hand end is in the form of a sleeve *K* into which there is screwed a block *L*. Fixed to the block is a wire rope *M* which extends throughout the whole length of the idler and is fixed to a similar bearing housing at the other end. Mounted loosely on the wire rope are a number of similar discs *N* each of which has a peripheral cylindrical flange *O* on each side. Mounted on each of the flanges *O* and on each of the projecting ribs *J* is a rubber tyre *P*. Adjacent rubber tyres bear against one another and thus provide a continuous rubber surface upon which a belt conveyor can rest. Further, the tyres prevent adjacent discs contacting with one another directly and the outer discs from coming into contact with the bearing housings. The resilience of the rubber tyres allows the idler to flex under load so that the belt on it assumes a trough shape. The degree of flexing of the idler caused by a given load may be regulated by varying the degree of axial compression of the rubber tyres when the idler is not under load. This adjustment is effected by adjusting the position of the block *L* within the sleeve *K*. The supporting arms *D* and *E* are connected at their lower ends by a linkage which ensures that, when a load is applied to the idler causing it to sag, the supporting arms pivot inwards and to move out again when the load is removed.—*February* 13, 1957.

## Launches and Trial Trips

BARFONN, shelter deck cargo liner; built by the Chantiers de France for Sigval Bergesen, Stavanger; length overall 520ft 3½in, length between perpendiculars 485ft 7in, breadth moulded 64ft 11½in, depth to shelter deck 41ft, draught 27ft 2in (open shelter) 30ft 2in (closed shelter), corresponding deadweights 12,792 tons and 14,560 tons, trial speed 16 knots; hold capacity 748,600 cubic feet; three 200kW diesel-driven generators, one 25kW diesel-driven emergency generator; one Sulzer 11 S.D. 72 two-stroke, single-acting diesel engine, eleven cylinders, 7700 h.p. at 125 r.p.m.

ELMINA PALM, cargo liner; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for the Palm Line, Ltd.; length between perpendiculars 425ft, breadth moulded 60ft, depth moulded to shelter deck 35ft 3in, deadweight 8000 tons on 23ft 5in mean draught; five cargo holds, one 40-ton, two 15-ton, two 10-ton and eight 5-ton derricks, electric winches; three 200kW diesel-driven generators; Swan, Hunter-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p. at 118 r.p.m.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

*Sat., March* 16.—OXFORD, READING AND DISTRICTS BRANCH: Regents Park College, Pusey Street, Oxford, "Specialised Spot Welding," C. G. Aldridge, 6.30 p.m.

*Tues., March* 19.—LONDON NATIONAL LECTURE: Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "The Theory and Practice of Plant Maintenance," H. V. Mather, 6.30 p.m. ★ YORK BRANCH: Royal Station Hotel, York, "Co-ordination between Lighting and Decoration," Raymond Pye, 7.30 p.m.

*Wed., March* 20.—NOTTINGHAM BRANCH: E. Midland Electricity Board, Smith Row, Nottingham, Annual Film Evening, 7.30 p.m.

*Sat., March* 23.—N. LONDON BRANCH: Visit to Ponders End Gas Works, 10 a.m.

### BELFAST ASSOCIATION OF ENGINEERS

*Wed., March* 20.—College of Technology, Belfast, "Diesel-Electric Traction," E. T. Bostock, 7.30 p.m.

### BRITISH INSTITUTION OF RADIO ENGINEERS

*To-day, March* 15.—SCOTTISH SECTION: Department of Natural Philosophy, University of Edinburgh, "Applications of Particle Accelerators," C. W. Miller, 7 p.m.

### CEMENT AND CONCRETE ASSOCIATION

*Tues., March* 19.—Cleveland Scientific and Technical Institution, Middlesbrough, "Some Notable Concrete Buildings," R. C. Blyth, 7 p.m. ★ Royal Empire Society, 18, Northumberland Avenue, London, W.C.2, "Modern Conceptions in the Planning of Bridges in Reinforced Concrete and in Prestressed Concrete," R. Morandi, 6 p.m.

*Wed., March* 20.—College of Further Education, Newtown Road, Hereford, "Concrete Formwork and Placing," E. Woodwark, 7.15 p.m. ★ Burnley Technical College, Burnley, "Some Notable Concrete Buildings," R. C. Blyth, 7.15 p.m.

*Thurs., March* 21.—Technical College, Great Horton Road, Bradford, "Control of Concrete Quality on Sites," R. A. Kenny, 7.15 p.m. ★ Polytechnic, Regent Street, London, W.1, "Development Trends in Building Plant," W. R. Matthews, 7 p.m.

### DIESEL ENGINEERS AND USERS ASSOCIATION

*Thurs., March* 21.—Caxton Hall, Westminster, London, S.W.1, "Fast-Running Lightweight Engines for Marine Duties," E. Chatterton, 2.30 p.m.

### ILLUMINATING ENGINEERING SOCIETY

*To-day, March* 15.—LEEDS CENTRE: Yorkshire Electricity Board, Ferensway, Hull, Annual General Meeting, 7 p.m.

*Tues., March* 19.—GLOUCESTER AND CHELTENHAM CENTRE: Fleece Hotel, Westgate Street, Gloucester, "The New Approach to Interior Lighting Design," J. M. Waldram, 6.30 p.m.

*Wed., March* 20.—N. LANCASHIRE GROUP: N.W. Electricity Board, 19, Friargate, Preston, "Recent Developments in Lighting Technique," J. Jansen, 7.15 p.m. ★ TEES-SIDE GROUP: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Town Planning and Lighting Problems," J. Worthington, 6.30 p.m.

*Thurs., March* 21.—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall, Manchester, "Recent Developments in Lighting Techniques," J. Jansen, 6 p.m.

*Fri., March* 22.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Street Lighting from a City Engineer's Point of View," Granville Berry, 6 p.m.

### INCORPORATED PLANT ENGINEERS

*Tues., March* 19.—WESTERN BRANCH: Grand Hotel, Bristol, Annual General Meeting, 7.15 p.m.

*Wed., March* 20.—E. MIDLANDS BRANCH: County Hotel, Theatre Square, Nottingham, Annual General Meeting, 7 p.m. ★ KENT BRANCH: King's Head Hotel, High Street, Rochester, "Optics as an Aid to the Engineer," John R. Adams, 7 p.m.

*Thurs., March* 21.—BLACKBURN BRANCH: Golden Lion Hotel, Annual General Meeting, 7.30 p.m. ★ LONDON BRANCH: College of Preceptors, Bloomsbury Square, London, W.C.1, "Pumping Plant in the Field," H. P. S. Paish, 7 p.m. ★ MERSEYSIDE AND N. WALES BRANCH: Stafford Hotel, City Road, Chester, "Welding and Testing of Welds by X-Rays," R. B. Whalley, 7.15 p.m.

*Fri., March* 22.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, Annual General Meeting, 7.30 p.m.

### INSTITUTE OF MARINE ENGINEERS

*To-day, March* 15.—SCOTTISH SECTION: Robert Gordon's College, Aberdeen, "The Wire Mill," R. Taylor, 7.30 p.m.

*Mon., March* 18.—STUDENT LECTURE: 85, Minories, London, E.C.3, "Gas Turbines," W. J. R. Stocks, 6.30 p.m. ★ S. WALES SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, Films on "Technicalities of the Petroleum Industry," 7 p.m.

*Tues., March* 19.—EDUCATION GROUP: 85, Minories, London, E.C.3, Annual General Meeting, followed by a Discussion on "A Comparison of the Training of Sea-Going Engineers in Other Countries," 5.30 p.m.

*Thurs., March* 21.—KINGSTON UPON HULL AND E. MIDLANDS SECTION: Hotel Metropole, Leeds, "Visual Observation of Stresses," J. Ward, 7.30 p.m.

### INSTITUTE OF METALS

*Mon., March* 18.—SHEFFIELD LOCAL SECTION: Engineering Lecture Theatre, The University, St. George's Square, Sheffield, "Materials of Construction in the Heavy Chemical Industry," F. M. Keating, 7.30 p.m.

### INSTITUTE OF PHYSICS

*Wed., March* 20.—LONDON AND HOME COUNTIES BRANCH: 47, Belgrave Square, London, S.W.1, "Semi-Conductors and the New Electronics," R. A. Smith, 6.30 p.m.

### INSTITUTE OF ROAD TRANSPORT ENGINEERS

*Thurs., March* 21.—Royal Society of Arts, John Adam Street, London, W.C.2, "The Design and Construction of a Modern Goods-Carrying Vehicle," A. S. C. Marks, 6.30 p.m.

### INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

*Wed., March* 20.—E. MIDLANDS CENTRE: Agriculture House, Lincoln, "Development of Power Frame Tractors," H. E. Ashfield, 7 p.m.

### INSTITUTION OF CHEMICAL ENGINEERS

*Wed., March* 20.—N.W. BRANCH: The University, Leeds, "A Study of the Motion of the Solid Phase in Liquid Fluidised Beds," N. L. Franklin and D. Handley, 7 p.m.

### INSTITUTION OF CIVIL ENGINEERS

*Tues., March* 19.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, "A Major Power Plan for Yukon River Waters in the Canadian Northwest," J. M. Wardle, 5.30 p.m.

*Thurs., March* 21.—N.W. ASSOCIATION: Engineers' Club, 17, Albert Square, Manchester, "Soil Mechanics in Municipal Engineering," R. G. Ashworth, 6.30 p.m. ★ GRADUATES' AND STUDENTS' SECTION: Great Northern Hotel, Leeds, "Civil Engineering Aspects of Atomic Energy," 7 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*To-day, March* 15.—N.E. GRADUATE AND STUDENT SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Electricity as an Aid to Coal Mining," R. Quayle and R. Strong, 6.30 p.m.

*Mon., March* 18.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "What is Limiting the Application of Servo-Mechanisms in the Electrical Industry?" opened by C. Ryder, 5.30p.m. ★ MERSEY AND N. WALES CENTRE: Town Hall, Chester, Joint Meeting with the N.W. Centre, "Highland Water Power: The Developments of the North of Scotland Hydro-Electric Board," 6.30 p.m. ★ N.E. RADIO AND MEASUREMENTS GROUP: King's College, Newcastle upon Tyne, "Power System Protection, with particular reference to the Application of Junction Transistors to Distance Relays," and "A Dual-Comparator Mho-Type Distance Relay Utilising Transistors," C. Adamson and L. M. Wedepohl, 6.15 p.m. ★ N.W. CENTRE: Town Hall, Chester, Joint Meeting with the Mersey and N. Wales Centre, "Highland Water Power: The Developments of the North of Scotland Hydro-Electric Board," 6.30 p.m. ★ W. SUPPLY GROUP: S.W. Electricity Board, Colston Avenue, Bristol, "Preventive Maintenance: Power Stations," P. L. Lutte; "Distribution," A. G. Milne, 6 p.m. ★ READING DISTRICT MEETING: George Hotel, King Street, Reading, "The Transatlantic Telephone Cable," R. J. Halsey, 7.15 p.m.

*Tues., March* 19.—E. MIDLAND CENTRE: College of Arts and Crafts, Waverley Street, Nottingham, "The Control and Instrumentation of a Nuclear Reactor," A. B. Gillespie, 6.30 p.m. ★ CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP: Cambridgeshire Technical College, Collier Road, Cambridge, "The Organisation and Progress of the Telephone Service," S. J. Edwards, 6.30 p.m. ★ N. MIDLAND UTILIZATION GROUP: C.E.A., Yorkshire Division, 1, Whitehall Road, Leeds, "Power Supply Problems in Coal Mining," D. C. Graham, 6.30 p.m. ★ S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "The Potentialities of Railway Electrification at the Standard Frequency," E. L. Wheatcroft and H. H. C. Barton, 7 p.m.

*Wed., March* 20.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "Recent Developments in X-Ray and Electron Microscopy with some Applications to Radio and Electronics," V. E. Cosslett and C. W. Oatley, 5.30 p.m.

*Thurs., March* 21.—ORDINARY MEETING: Savoy Place, London, W.C.2, "A Cyclotron for Medical Research," J. W. Gallop, D. D. Vonberg, R. J. Post, W. B. Powell, J. Sharp and P. J. Waterton, 5.30 p.m. ★ IRISH BRANCH: Physical Laboratory, Trinity College, Dublin, "Variable-Speed A.C. Drives," J. A. V. McEvoy, 6 p.m.

### INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*Tues., March* 19.—The Lorne, 69, West Blackhall Street, Greenock, "Techniques for Hydraulic Machinery Research," S. P. Hutton, 7.30 p.m.

### INSTITUTION OF HEATING AND VENTILATING ENGINEERS

*Wed., March* 20.—YORKSHIRE BRANCH: Griffin Hotel, Leeds, "Geo-Thermal Heating in New Zealand," G. M. Hoyle, 7.30 p.m.

### INSTITUTION OF HIGHWAY ENGINEERS

*Fri., March* 22.—N.E. BRANCH: The University, Palace Green, Durham City, "Surveying, including the Use of Instruments and Drawing Office Materials," 7 p.m.

### INSTITUTION OF LOCOMOTIVE ENGINEERS

*Wed., March* 20.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Annual General meeting, followed by "Unification of Freight Vehicles on Oversea Railways," A. Campbell, 5.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

*To-day, March* 15.—LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Factors in the Handling of Lubricants," 6.45 p.m.

*Mon., March* 18.—DERBY BRANCH: Rolls-Royce Welfare Hall, Nightingale Road, Derby, Joint Meeting with the Derby Branch of the Royal Aeronautical Society, "Some Operating Problems of Jet Air Liners," W. O. W. Challier, 6.15 p.m. ★ SCOTTISH A.D. CENTRE: 39, Elmbank Crescent, Glasgow, "Rubber Springs for Vehicle Suspension," A. E. Moulton and P. W. Turner, 7.30 p.m. ★ MIDLAND GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Nuclear Power," I. Wans, 6.45 p.m.

*Tues., March* 19.—N. WESTERN A.D. CENTRE: Engineers' Club, 17, Albert Square, Manchester, "Experiences During Forty Years of Automobile Design," A. G. Booth, 7.15 p.m.

*Wed., March* 20.—N. EASTERN A.D. CENTRE: Chemistry Lecture Theatre, University, Leeds, "Transmission Developments for Public Service and Heavy Goods Vehicles," A. Gordon Wilson, 7.30 p.m.

*Thurs., March* 21.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Motor-Cycle or Miniature Car?" 6.45 p.m. ★ LONDON GRADUATE SECTION: Visit to Belling and Co., Ltd., Enfield, Middlesex, 2 p.m. ★ YORKSHIRE GRADUATE SECTION: Chemistry Lecture Theatre, University, Leeds, Discussion Evening, 6.30 p.m.

*Fri., March* 22.—1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, 6 p.m.

### INSTITUTION OF MINING AND METALLURGY

*Thurs., March* 21.—Geological Society of London, Burlington House, Picsadilly, London, W.1, "Separation of Uranium and Copper during the Acid Pressure Leaching of Sulphidic Uranium Ores," J. Halpern and F. A. Forward, and "Hydro-Metallurgical Processes at High Temperatures," F. A. Forward and J. Halpern, 5 p.m.

### INSTITUTION OF NAVAL ARCHITECTS AND INSTITUTE OF MARINE ENGINEERS

*Tues., March* 19.—S. JOINT BRANCH: Southampton Technical College, St. Mary's Street, Southampton, "Developments in Marine Electrical Installations with particular reference to A.C. Supply," A. N. Savage, 7.30 p.m.

### INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

*Wed., March* 20.—INFORMAL MEETING: Waterloo Bridge House, London, S.E.1, "Lighting to Assist the Engineer." D. J. Harris, 5 p.m.

### INSTITUTION OF PRODUCTION ENGINEERS

*To-day, March* 15.—WEST WALES BRANCH: Central Library, Alexandra Road, Swansea, "Lithographic Printing," 7.30 p.m.

*Mon., March* 18.—SHEFFIELD BRANCH: City Memorial Hall, Sheffield, George Bray Memorial Lecture, "The Organisation of Operational Research," Stafford Beer, 6.30 p.m. ★ Grand Hotel, Hanley, Stoke-on-Trent, "Human Relations in Industry," D. W. Collier, 7.30 p.m. ★ N.E. BRANCH: Neville Hall, Newcastle upon Tyne, "Production Control for General Engineering at Home and in the U.S.A.," T. Nancarrow, 7 p.m.

*Wed., March* 20.—MIDLANDS REGION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Modern Techniques in Die Casting Practice," J. Bailey, 7 p.m. ★ WOLVERHAMPTON GRADUATE SECTION: Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton, "The Development and Manufacture of Jig Boring Machinery," W. H. Jaye, 7.30 p.m. ★ E. REGION: Assembly House, Theatre Street, Norwich, "The Design of Road Transporters for Loads of Over 100 Tons," W. D. Chadlin, 8 p.m.

*Thurs., March* 21.—Royal Empire Society (Craven Street Entrance), Northumberland Avenue, Strand, London, W.C.2, "Galvanizing," L. F. Chambers, and "Metal Spraying," G. A. Curson, 7 p.m. ★ SCOTTISH REGION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Ferrous Die Casting," C. A. Payne, 7.30 p.m. ★ N. IRELAND REGION: Kensington Hotel, College Square East, Belfast, "Time and Motion Study," Miss Anne Shaw, 7.30 p.m.

*Fri., March* 22.—N.E. GRADUATE: Roadway House, Oxford Street, Newcastle, "The Development of Earth Moving Tractors," C. Hunt, 7 p.m.

### INSTITUTION OF THE RUBBER INDUSTRY

*Tues., March* 19.—MERSEYSIDE SECTION: Liverpool Corporation Passenger Transport Office, 24, Hatton Garden, Liverpool, "Extruders and Extruding," A. Crowther and Mr. Robinson, 7.15 p.m.

### INSTITUTION OF STRUCTURAL ENGINEERS

*Tues., March* 19.—LANCASHIRE AND CHESHIRE BRANCH: College of Technology, Manchester, "Some Aspects of Research Work on Prestressed Concrete," R. H. Evans, 6.30 p.m. ★ SCOTTISH BRANCH: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Construction of New Iron and Steel Works: Colvilles, Ltd., Ravenscraig, Motherwell," Andrew Young, 7 p.m.

*Fri., March* 22.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Structural Aspects of the 'Big Top' Site Development," R. Bolsover and E. J. Spillett, 6 p.m. ★ S.W. COUNTIES BRANCH: Duke of Cornwall Hotel, Plymouth, "Law and the Engineer," S. P. Whittington, 6 p.m.

### JUNIOR INSTITUTION OF ENGINEERS

*To-day, March* 15.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Astronautics To-day and Tomorrow," G. V. E. Thompson, 7 p.m.

*Fri., March* 22.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Gas Chromatography," H. W. D. Hughes, 7 p.m.

### LIVERPOOL METALLURGICAL SOCIETY

*Thurs., March* 21.—Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Steels at Elevated Temperatures," J. D. Murray, 7 p.m.

### MANCHESTER ASSOCIATION OF ENGINEERS

*To-day, March* 15.—Engineers' Club, Albert Square, Manchester, "Industrial Television," J. E. H. Brace, 6.45 p.m.

### MANCHESTER GEOLOGICAL AND MINING SOCIETY

*Thurs., March* 21.—Wigan and District Mining and Technical College, Wigan, "Architecture at Collieries," J. H. Bourne, 3.15 p.m.

### NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*Wed., March* 20.—STUDENT SECTION: Bolbec Hall, Newcastle upon Tyne, "The Development of Yacht Design," B. D. Jones, 6.45 p.m.

*Fri., March* 22.—ANDREW LAING LECTURE: Literary and Philosophical Society, Newcastle upon Tyne, "Structural Steels for Warship Building, with Some Notes on Brittle Fractures," Sir Victor Shepheard, 6.15 p.m.

### REINFORCED CONCRETE ASSOCIATION

*Tues., March* 19.—SCOTTISH BRANCH: North British Hotel, Princes Street, Edinburgh, "Allt-Na-Lairige Prestressed Concrete Dam," J. A. Banks, 6.30 p.m.

### ROYAL AERONAUTICAL SOCIETY

*Tues., March* 19.—GRADUATES' AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, "Gas Turbines for Helicopters," A. W. Morley, 7.30 p.m.

*Thurs., March* 21.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "The Application of Automatic Digital Computers to Aeronautical Problems," S. H. Hollingdale, 7 p.m.

### ROYAL STATISTICAL SOCIETY

*Wed., March* 20.—ORDINARY MEETING: London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "The Measurement of Productive Efficiency," M. J. Farrell, 5.15 p.m.

### SOCIETY OF CHEMICAL INDUSTRY

*Thurs., March* 21.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, a Symposium on "The Corrosion of Metals in Buildings," 9.30 a.m.

### SOCIETY OF INDUSTRIAL RADIOLOGY

*Fri., March* 22.—Grand Hotel, Bristol, "Modern Trends in Non-Destructive Testing," R. S. Sharpe, 7 p.m.

### SOUTH WALES INSTITUTE OF ENGINEERS

*Thurs., March* 21.—Park Place, Cardiff, "The Cynheidre Sinking," G. Tomkins, 6 p.m.

### WEST OF SCOTLAND IRON AND STEEL INSTITUTE

*To-day, March* 15.—39, Elmbank Crescent, Glasgow, Joint Meeting with the Iron and Steel Engineers' Group, "A Review of Some Rolling Mill Engineering Practices," F. G. Thomson, 6.45 p.m.